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MACHINE TOOLS

Wm. Sellers & Co.

1884

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Mr W. R. Eckart

with compliments,

Wm Sellers & Co

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A TREATISE

ON

MACHINE-TOOLS, ETC.

AS MADE BY

WM. SELLERS & CO.,

1600 Hamilton Street, Philadelphia, U.S.,

MANUFACTURERS OF

MACHINISTS', FOUNDERS', SMITHS', AND BOILER-MAKERS' TOOLS,

SHAFTING AND MILL GEARING,

RAILWAY TURNING AND TRANSFER TABLES,

PIVOT BRIDGES, ETC.;

MANUFACTURERS OF THE

MOST IMPROVED FORMS OF INJECTOR BOILER-FEEDERS,

AND

SOLE MANUFACTURERS OF THE SELF-ADJUSTING INJECTOR.

SIXTH EDITION, REVISED.

WITH FULL TEXT OF THE REPORT OF JUDGES ON THE EXHIBIT OF WM. SELLERS & CO., AT THE INTERNATIONAL EXHIBITION, PHILADELPHIA, 1876, AND EXTRACTS FROM REPORT TO BRITISH PARLIAMENT BY DR. JOHN ANDERSON, LL.D., C.E.

PHILADELPHIA.

1884.

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J. B. LIPPINCOTT & CO.,
PHILADELPHIA.

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INTRODUCTION

TO

EDITION OF 1877.

HAVING exhausted the edition of our Treatise for 1876, we issue a new one for 1877, containing the report of the judges on our exhibits at the Great World's Fair, held in Philadelphia.

This edition, like those that preceded it, has in view the one object, to present to users of machine tools such a description of the various machines made by us as is usually given verbally to those who visit our works to purchase. We do not pretend to make it a treatise on machine tools in general, but we aim to describe such tools as we make, to show their adaptation to their intended uses, and to give some hints as to how to work them to the best advantage.

The rapid advancement of engineering, rendered possible by the invention of machines to do the work required, demands constant addition to the list of such machines. New wants are every day arising, requiring fresh exertion of designing skill in the production of tools to meet these wants, so that any book descriptive of this kind of machinery can only embody what was in operation at the time it went to the press.

At the closing of any great international exhibition users of machines naturally look to the opinion of the international judges in reference to quality of those machines exhibited. Our display at the Centennial Exhibition was large, and representative of our leading productions. The report of the judges accompanying the awards to us was full and comprehensive, and of great value when

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considered in reference to the opinion of judges at former exhibitions.

International exhibitions of the industries of the various peoples of the world have come to be considered matters of necessity with all great nations. The works entered for competition at such times are judged, not by their standing at home, but in comparison with similar products from all parts of the world. The judges appointed are experts from various countries, selected by the commissioners having charge of the interests of each country; and those judges who have distinguished themselves at one great exhibition, have, in many cases, been selected to act in the same capacity in others, so that some men come to each new contest with enlarged experience, gathered at many world's fairs.

To celebrate the completion of the first century of the independence of the United States, the Centennial Exhibition was wisely originated, and has been carried to a successful termination with credit to our country.

A new system of awards has been tried for the first time, and as this system of 1876 differs essentially from what had obtained in former exhibitions, a few words of explanation are deemed necessary, as a prelude to the wording of the text of awards to us.

At all previous international exhibitions, graded awards, expressed by medals of gold, silver, and copper, alone indicated the opinion of the international judges. The American system of awards of 1876 was based on the opinion of the judges on awards expressed in writing, in a report or a diploma, accompanying one uniform medal of copper to all successful exhibitors. The value of this award lies in the wording of the report, not in the value of the metal forming the medal. The diploma or report, which is the real award, emanates from the Centennial Commission, and bears the signature of its officers and the seal of the corporation. This action of the Commission, however, is only an indorsement of the work of the Group Judges, and the wording of the diploma is the wording of the Examining Judge who wrote the original

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recommendation for award, which in addition is countersigned by his co-workers, in the Group, who thus express their approval of his action.

The International Jury of 1876 was arranged so as to assign foreign and native judges to each group or subdivision of the objects exhibited. These Group Judges, in organizing, elected their own chairman and secretary. They then examined the most important exhibits in company, delegating one of their number to write the recommendation for award in each case, after which these recommendations were considered at the meetings of the Group, and if approved were countersigned by all the members of that Group. This examination by the Group in a body, and their final action as evinced by their signatures, was designed to insure uniformity in method pursued, and as far as possible to grade the expressions of commendation in awards.

Of our own exhibit at the Centennial, much the largest part was classed in Group XXI., Steam Hammers and Machine Tools; classes 514 and 515 forming an important part of the objects assigned to that group.

The judges appointed for the examination of Group XXI. were:

Mr. JOHN ANDERSON, LL.D., C.E., etc.	*Woolwich Arsenal, G. Br.*
Prof. C. A. ANGSTROM	*Sweden.*
Mr. AUGUST GOBERT, Jr.	*Belgium.*
Mr. F. REIFER	*Austria.*
M. LE COMMANDANT F. PERRIER . .	*France.*
Mr. GEORGE H. BLELOCH	*Springfield, Mass.*
Mr. W. F. DURFEE	*New York City.*
Mr. IRVING M. SCOTT	*Union Iron Works, San Francisco, Cal.*
Prof. J. A. ANDERSON	*Manhattan, Kansas.*

Dr. John Anderson was chosen Chairman.

In complimenting Dr. Anderson, of Great Britain, by placing him at the head of Group XXI., his experience at all other great international exhibitions was recognized. Few men have become so

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thoroughly identified with any one great industrial interest as he has, by his researches as a scientific expert, in this particular division of mechanical engineering. In noting him as the author of the wording of the award to us it must be borne in mind that he had studied our exhibit in comparison with others in Paris, in 1867, where we were awarded the gold medal, and he was one of those judges in Vienna who recommended to us the award of the Grand Diploma of Honor in 1873.

At Vienna five distinct bronze medals marked the nature of award to superior exhibits, but above all was placed the

GRAND DIPLOMA OF HONOR.

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"Designed to bear the character of peculiar distinction for eminent merits in the domain of science and its application to the education of the people, and the advancement of the intellectual, moral, and material welfare of man." It was awarded exclusively by the Council of Presidents upon the proposition of the International Jury.

This diploma reads:

WORLD'S FAIR, 1873, IN VIENNA.
THE INTERNATIONAL JURY HAVE DECREED
TO THE FIRM OF
WILLIAM SELLERS & CO.,
IN PHILADELPHIA, PENNSYLVANIA,
UNITED STATES OF NORTH AMERICA,
FOR MACHINE TOOLS,
THE HIGHEST DISTINCTION,
THE DIPLOMA OF HONOR.

The recommendation for this award was to—

"SELLERS. For pre-eminent achievements in the invention and construction of machine tools, many of which have been adopted as patterns by the constructors of tools in all countries."

Dr. Anderson was an active participant in the Paris and Vienna Exhibitions, and in other great world's fairs, so that considering the fullness of his knowledge on this subject, his wording of the report to accompany the award to us at the Centennial comes with special force, and gives point to the expressions used on page XII in the prelude to the recommendation. The wording of this report will be seen to be of very much greater value than the awards made on the old plan of graded medals, and shows a full appreciation, by the Judges of this Group, of the true spirit of the system of 1876.

The gold medal of Paris, 1867, which we value highly as the prelude to the award at Vienna and in Philadelphia, has a certain moneyed value, measured by its weight of precious metal; to this is added the greater fictitious value of its indicative award, but its value as an award consists only in its rarity. If but to one exhibit

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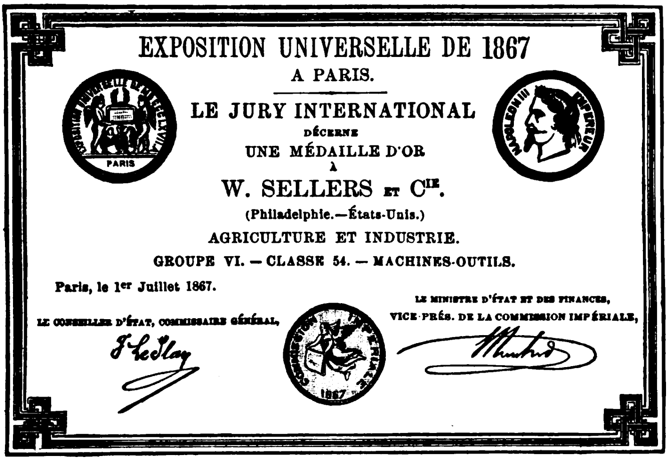
in each Group such an award be made, its real value is gauged by that fact alone.

The American system admits of many premiums, made more or less valuable by the expressed opinions of the judges recommending the awards, with the further advantage of giving in the language of the Examining Judge an expression of opinion which may constitute a valuable contribution to knowledge. This is of more value than the most costly medal, unaccompanied by such report. With the gold medal of Paris, 1867, came only a framed diploma as below:



EXPOSITION UNIVERSELLE DE 1867
A PARIS.
LE JURY INTERNATIONAL
DÉCERNE
UNE MÉDAILLE D'OR
À
W. SELLERS ET CIE.
(Philadelphie.—États-Unis.)
AGRICULTURE ET INDUSTRIE.
GROUPE VI. — CLASSE 54. — MACHINES-OUTILS.

Paris, le 1er Juillet 1867.

LE CONSEILLER D'ÉTAT, COMMISSAIRE GÉNÉRAL,

LE MINISTRE D'ÉTAT ET DES FINANCES,
VICE-PRÉS. DE LA COMMISSION IMPÉRIALE,

This is all the knowledge imparted as to the opinion of the Paris judges.

Our exhibit of Shafting and Mill Gearing, as also of Injectors, at the Centennial, came under the consideration of Group XX., the list of judges of the Group being—

Mr. W. H. Barlow, C. E. . . . . *Great Britain.*
Prof. Reuleaux . . . . *Germany.*
Mr. Nicholas Petroff . . . . . *Russia.*

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Mr. Emil Brugsch	*Egypt.*
Mr. C. T. Porter	*Newark, N. J.*
Mr. Joseph Belknap	*New York.*
Mr. James Moore	*Philadelphia.*
Mr. Horatio Allen	*S. Orange, "Homewood," N. J.*
Mr. Charles E. Emery	*New York.*

Their recommendations upon which the awards were made to us for Shafting, Couplings, etc., and for Injectors, are given on pages xxii and xxiii.

Our display at Philadelphia was much larger than at either Paris or Vienna, and, as in those cases, was taken from stock, no unusual care having been bestowed on its preparation for this examination.

We exhibited at the Centennial—

One 16 inch Lathe, 7 feet 10⅝ inches long.
One 20 inch Lathe, 9 feet 9½ inches long.
One 48 inch Lathe, 17 feet and ¾ inch long.
One 20 inch Chasing Lathe.
One 80 inch Wheel Lathe.
One 30 inch Planer, to plane 10 feet long.
One 54 inch Planer, to plane 16 feet long.
One 120 inch Planer, to plane 30 feet long.
One 12 inch Shaper.
One 36 inch Slotter.
One 60 inch Slotter.
One Gear-cutter.
One ¾ inch Bolt-cutter.
One 2½ inch Bolt-cutter.
One 45 inch Vertical Drill.
One Horizontal Drill.
One 2½ tons Steam Hammer.
One 1500 pounds Steam Hammer.
One 300 pounds Steam Hammer.
One Hydraulic Riveter and Connections.
One 52 inch Punch.
One Bar Shear.
One 60 inch Plate Shear.
One Angle Shear.
One Punch and Shear combined.
One 48 inch Car-wheel Boring Mill.
One 84 inch Boring and Turning Mill.
One 72 inch Hydrostatic Wheel Press.
One Wheel Quartering Machine.
One Cylinder Boring Machine.
One Surfacing Machine.
One Drill-grinding Machine.
One Nut-shaping Machine.

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Our exhibit of Shafting and Mill Gearing consisted of lines i operation over our own space, and, in addition, rather more than one-half of all the line shafting used to transmit power in Machinery Hall, and all in Brewers' Hall, was made and put up by us. The Injectors for feeding boilers, included in our display, consisted of various forms of self-adjusting and adjustable Injectors, and, in addition, the new form of our self-adjusting instrument, or Injector of 1876. This is a modification of Mr. Giffard's celebrated invention, embodying the principle of our self-adjusting instrument, with additions, that make it operative by the motion of one single working lever. This improvement renders it of special service on locomotives, as it does away entirely with all complication of starting and regulating appliances, and renders its operation and adjustment as simple as the opening and closing of the throttle valve of the engine.

It will be seen that we have had three distinct awards adjudged to us, and the very full account of the points of merits claimed for our Machine Tools as expressed by Dr. Anderson in his report has decided us to present, to users of such tools, the text of the award in its present form.

WILLIAM SELLERS & CO.

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REPORT OF THE JUDGES

ON THE EXHIBIT OF

WM. SELLERS & CO.

INTERNATIONAL EXHIBITION,

PHILADELPHIA, 1876.

THE United States Centennial Commission has examined the report of the Judges, and accepted the following reasons, and decreed an award in conformity therewith:

PHILADELPHIA, July 1, 1876.

REPORT ON AWARDS.

PRODUCT: Steam Hammers and Machine Tools.

Name and Address of Exhibitors: William Sellers & Co., Philadelphia, Pa

The undersigned, having examined the product herein described, respectfully recommends the same to the United States Centennial Commission for award, for the following reasons, viz.:

For a remarkable collection of machine tools for working metal. This exhibit when considered in regard to its extent and value, its extraordinary variety and general excellence, as also for the large amount of originality that is shown in the numerous new devices that are introduced, is probably without a parallel in the past history of international exhibitions, and taken as a whole, it is worthy of the highest honor that can be conferred. Besides, it is thoroughly national in its characteristics, and pre-eminently worthy of the

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United States and of the grand occasion of the Centennial Exhibition.

Every single machine, tool or piece of apparatus that is displayed in this vast offering would for itself command the strongest recommendation for an award, even if it stood alone as a unit; but here every unit is surrounded by thirty-three distinct machines, each one being of the highest standard in its particular class. The whole of these machines are characterized by extreme refinement in every detail; by the superior quality of the material employed in their construction; by first-class workmanship, both in regard to nice fitting and precision, and for the mathematical accuracy of all the parts; by the beautiful outlines that are imparted to each structure; by the correct proportions that have been worked out in the determining of strength and form; and the disposal of material to take full share of duty. For the scientific skill displayed in the application of mechanical force, for the daring shown in fearlessly breaking through the trammels of the past, by introducing variously constructed devices and arrangement of gearing for the transmission of power in more direct course to the point of action, yet maintaining correct construction mechanically, and without departure from true principles. As it is impossible to realize the full measure of such refined mechanical, scientific, and artistic merit, by the foregoing remarks, it is deemed necessary to enumerate briefly some of the more prominent points in the several machines, both in justice to the exhibitors and to the judges.

MACHINE FOR GRINDING TRUE SURFACE PLATES.

(*See page* 40.)

Commended for originality both in regard to the idea or principles of this machine, and also for the design and development into a practical tool for the engineer, whereby a surface which is mathematically a true plane can be transferred to other surfaces, even of the most obdurate materials, either hardened steel or chilled cast iron, the means employed being simple and inexpensive.

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STEAM HAMMERS.

(*See pages* 232 *to* 244.)

Commended for general excellence of construction throughout, more especially for originality in the form and arrangement of the working hammer, and likewise the hammer head, and for the manner in which the head is secured to the hammer, and for the practical results which flow from the arrangements, and the convenience of fixing and unfixing which the combination affords. For originality in the mode of working the steam valve, and for the introduction of several marked improvements in connection therewith, by which the steam part of the apparatus is put under favorable conditions for efficiency, either for automatic working or by hand, and by which the blow is effectually controlled.

PLANING MACHINES.

(*See pages* 156 *to* 174).

Commended for originality, general excellence, and refined mechanical skill in the construction of planing machines for metal.

New combinations of gearing, made up of various original devices, are introduced, whereby greater efficiency, strength, and economy are obtained, as well as a soft, uniform, easy motion, to afford smooth planing.

For originality in the various arrangements connected with the belt motions; for convenience of manipulation by the attendant, to avoid the usual struggle between the open and cross belts at the reversing points, thus economizing power and avoiding wear and tear.

Also, for originality in the means employed for giving the feed motion at the proper nick of time, as also for the arrangement which raises the cutting instrument from the work during the return of the planing table, which is both direct and decisive; and as a whole, the belt and feed combination is characterized by great

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mechanical refinement, the result of matured thought and experience.

SELF-ACTING AND SCREW-CUTTING LATHES.

(*See pages* 106 *to* 135.)

Commended for general excellence and extreme mechanical refinement in all the details that determine accuracy of production in regard to true circles, true cylinders, and true planes. For originality in the method adopted for fixing the shifting head, the introduction of an under V within the bed, whereby the head is always drawn up to the same straight line in the mathematical sense, and thus avoiding the necessity of a tight fit and its attendant disadvantages. For the adoption of a method which insures the retention of truth in spindles, and more especially in their relation to their centres. For originality both in the conception and design of an admirable system of feed motion, consisting of a simple combination of disks, whereby the feed rate may be altered from one extreme to another, or to any intermediate point, by a momentary touch of the attendant, thus affording the skillful and zealous workman an opportunity of developing the produce of the lathe to its utmost capacity, and along with that the reduction of cost.

CHASING LATHE FOR BRASS WORK.

(*See pages* 144 *and* 145.)

Commended for originality and general excellence in its design and construction, and for a simple combination of mechanical devices to serve a special purpose, whereby the turning, boring, and screwing of brass work generally may be executed with great accuracy, as well as more rapidly and economically than can be done in an ordinary lathe; as in it the functions are general, but here they are more special in their adaptation to a class and consequently more convenient.

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WHEEL TURNING LATHE.

(*See pages* 148 *to* 151.)

Commended for its great stability and general excellence of construction as a machine tool, and for the convenient adaptation of various devices to a special purpose of great importance, namely, for turning the driving wheels of a locomotive correctly, and at the minimum of time and cost, with such arrangements as will enable both wheels to be acted upon at the same time. The beautiful outlines and the grandeur of this tool are worthy of highest commendation.

BORING AND TURNING MILL.

(*See pages* 95 *to* 97.)

Commended for its sterling qualities as a machine tool, more especially with reference to its utility and accuracy. It is also distinguished for the manner in which the material is disposed as well as in regard to the forms and general proportions of the parts, and its adaptation to the intended special purpose, to obtain mechanical truth and accuracy at a moderate cost.

MACHINES FOR GRINDING DRILLS.

(*See pages* 25 *to* 39.)

Commended for originality in the idea and excellence of the design of an apparatus for grinding the edge of drills in such a manner as will insure mathematical accuracy, both in the angle and the cutting edges, at the minimum of cost, by which means the drill instrument is rendered more efficient; it performs more and better work than is practically obtainable by the usual system, even in the hands of a skilled workman.

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CAR WHEEL BORING MILL.

(*See page* 101.)

Commended for the general excellence of design and construction, and the admirable adaptation to a special purpose, which has to be repeated an indefinite number of times in order to perform the operation accurately and economically. To meet these conditions, various adjustments are provided, by means of which the car wheels are conveniently put on to the machine, then bored and faced, and removed from the machine in shorter time than would be required in the ordinary boring and turning lathe.

AUTOMATIC GEAR-CUTTING AND DIVIDING MACHINE.

(*See pages* 297 *to* 301.)

Commended for the great mechanical perfection in its various functions, to perform operations both difficult and recondite, and which for the particular purpose is without a compeer. The designer of this machine has so embodied his own mental faculties into its material combinations that they are involuntarily constrained to do his will, when power is applied, and without any human assistance. All this it performs with the utmost accuracy, and at the minimum of cost.

CYLINDER BORING AND FACING LATHE.

(*See page* 89.)

Commended for the remarkable excellence of the general design, and for the sterling qualities that pervade the details throughout. This grand tool is an embodiment of all the tool virtues that can be enumerated, resulting in the transmission of mathematical truth and accuracy to the work performed, combined with great

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rapidity of execution and consequent economy, thus realizing the highest ideal conditions. Still more, this machine is constructed in such a manner as will enable it to maintain its inherent faculties unimpaired for a long time.

SLOTTING MACHINE.

(*See pages* 193 *to* 196.)

Commended for originality of construction, especially in the part in which the slotting bar slides, whereby stiffness is imparted and a steady cutting action; and for the manner in which the machine is fitted with best known arrangements for giving the proper rate of motion to the cutting instrument with a quick return; also, for the refined and convenient arrangement whereby the feed is given at the exact and proper nick of time in relation to the stroke.

SHAPING MACHINE.

(*See pages* 186 *to* 190.)

Commended for general excellence as a shaping or planing tool, with the most approved devices for actuating the cutting and return motions, and for the perfect arrangement to secure truth and parallelism in the work performed, and in order that the parts may retain their faculties during a long period of hard work, which is a high virtue in a tool of this class.

HORIZONTAL DRILLING AND BORING MACHINE.

(*See page* 70 *to* 76.)

Commended for originality and general excellence in design, especially in regard to the introduction of the disk feed-motion, whereby the production of the machine may be increased. Also,

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for the addition of what is called a "coarse feed," by which finishing cuts may be performed more rapidly and with equal efficiency. Also, for the very convenient arrangement of the manipulation handles, and for avoiding all embarrassment to the workmen in the performance of various operations to which the machine may be applied.

WHEEL QUARTERING MACHINE.

(*See pages* 84 *to* 86.)

Commended for, first, conception of the idea, and second, for devising the way in which the idea was to be carried out, and for the extreme care and accuracy that have been bestowed upon its construction to insure absolute truth in the division. Considered for its manifest utility and perfect adaptation to perform a most difficult operation, this tool is a most valuable addition to the engineering workshop.

DOUBLE GEARED VERTICAL DRILL.

(*See pages* 44 *to* 53.)

Commended for the general excellence of the design, and for certain original modifications by which the efficiency of the machine is improved both in regard to quality and quantity of produce.

BOLT AND NUT SCREWING MACHINE.

(*See pages* 4 *to* 11.)

Commended for general excellence of design, and for many distinct points of originality, all pointing to increased efficiency, as regards accuracy, rate of production, durability, and convenience;

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likewise for new devices to secure more perfect flooding of the work with oil during the cutting, and for the economizing of the oil so treated. This is probably the most perfect machine which has been constructed for this purpose, and deserves the highest commendation.

COMBINED PUNCHING AND SHEARING MACHINE.

(*See pages* 199, 200.)

Commended for general excellence of design, for the proportions of strength at particular points to meet successive strains, and for the soundness of the entire structure; also, for the convenient manner in which the punching die is arranged in order to give facility for operating upon varied and intricate forms of articles; as also for the very perfect stop motions that are applied both to the punching and shearing slides.

NUT-SHAPING MACHINE.

(SYSTEM, BATHO.)

Commended for originality and great efficiency, and for its construction upon an entirely new idea and principle of arrangement. In connection with this machine, commendation to distinct parties is due. First, to the inventor, for the original design and its special fitness for a purpose; for its general utility to supply an extensive want; and for the economic production which it affords. Second, to its makers, Messrs. William Sellers & Co. (the exhibitors), for three distinct points of originality which they have introduced into the machine, and for superiority in its construction.

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PLATE SHEARING MACHINE.

(*See pages* 216, 217.)

Commended for great originality in its arrangement, the excellence of its general design, and the admirable manner in which various ideas have been combined and reduced into a harmonious, sound, and convenient practical tool; also, for convenient arrangement to afford handy manipulation, precision in cutting to any determined point upon a line (the determining motions being automatic), and for skillful distribution of the shearing strains, and their entire expenditure within the structure.

ANGLE SHEARING MACHINE.

(*See page* 212.)

Commended for originality, and for the sound and scientific principles which have been displayed in its arrangements and construction. For the avoidance of certain mechanical errors that are too common, whereby inordinate friction is developed at certain vital points of action. In this machine these pressures are distributed by simple means, thus affording greater permanence of wearing parts, economy of power, increase of capacity, and other advantages. Such combinations are the result of close thinking by men who are engineers "to the manner born."

HYDRAULIC RIVETING MACHINE.

(SYSTEM, TWEDDELL.)

(*See pages* 256 *to* 272.)

Commended for originality of high order. In connection with this machine commendation to distinct parties is due. First, to the inventor, for the original ideas that are embodied; for the original design; and for the combination of well-known mechanical or hy-

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draulic devices or apparatus, whereby an important advance has been made in the execution of great works of construction; for simplicity of means affording a controlled pressure, promptitude and certainty of action, and which is accomplished in silence. Secondly, to the makers and exhibitors, William Sellers & Co., for their superiority of construction, and for the introduction of certain original devices by means of which the efficiency of the machine is improved, the power required to work it reduced, the accumulation simplified, and the weights are more conveniently arranged for being shifted for the determination of pressure; and likewise for the admirable manner in which the best materials and workmanship have been combined in order to insure success in the development of this new and most valuable apparatus before the engineers of America.

[Signature of the Judge.] JOHN ANDERSON.

APPROVAL OF GROUP JUDGES.

GEO. H. BLELOCH,	JOHN A. ANDERSON,	AUG. GOBERT, fils,
F. REIFER,	C. A. ANGSTROM,	F. PERRIER.
W. F. DURFEE,		

A true copy of the record.

FRANCIS A. WALKER,
Chief of the Bureau of Awards.

Given by authority of the United States Centennial Commission.

A. T. GOSHORN,	J. L. CAMPBELL,	J. R. HAWLEY,
Director-General.	*Secretary.*	*President.*

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INTERNATIONAL EXHIBITION,

PHILADELPHIA, 1876.

THE United States Centennial Commission has examined the report of the Judges, and accepted the following reasons, and decreed an award in conformity therewith.

PHILADELPHIA, NOV. 29, 1876.

REPORT ON AWARDS.

PRODUCT: Shafting, Couplings and Hangers.
Name and Address of Exhibitors: William Sellers & Co., Philadelphia, Pa.

The undersigned having examined the product herein described, respectfully recommends the same to the United States Centennial Commission for award, for the following reasons, viz.:
Well-established excellence in workmanship and design.

[Signature of the Judge.] W. H. BARLOW.

APPROVAL OF GROUP JUDGES.

W. PETROFF,	HORATIO ALLEN,	F. REULEAUX,
CHAS. E. EMERY,	CHAS. T. PORTER,	EMIL BRUGSCH.

A true copy of the record.

FRANCIS A. WALKER,
Chief of the Bureau of Awards.

Given by authority of the United States Centennial Commission.

A. T. GOSHORN,	J. L. CAMPBELL,	J. R. HAWLEY,
Director-General.	*Secretary.*	*President.*

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INTERNATIONAL EXHIBITION,

PHILADELPHIA, 1876.

The United States Centennial Commission has examined the report of the Judges, and accepted the following reasons, and decreed an award in conformity therewith.

PHILADELPHIA, NOV. 29, 1876.

REPORT ON AWARDS.

PRODUCT: Injector.

Name and Address of Exhibitors: William Sellers & Co., Philadelphia, Pa.

The undersigned having examined the product herein described, respectfully recommends the same to the United States Centennial Commission for award, for the following reasons, viz.:

That they exhibit an Injector that is self-regulating, is simple in plan, readily operated, and is in material and workmanship of the highest order.

[Signature of the Judge.] HORATIO ALLEN.

APPROVAL OF GROUP JUDGES.

CHAS. T. PORTER,	EMIL BRUGSCH,	W. H. BARLOW,
W. PETROFF,	F. REULEAUX,	CHAS. E. EMERY.
JOSEPH BELKNAP,		

A true copy of the record.

FRANCIS A. WALKER,
Chief of the Bureau of Awards.

Given by authority of the United States Centennial Commission.

A. T. GOSHORN,	J. L. CAMPBELL,	J. R. HAWLEY,
Director-General.	*Secretary.*	*President.*

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EXTRACTS FROM THE REPORT OF DR. JOHN ANDERSON, LL.D., C.E., BRITISH COMMISSIONER, ETC.

UPON the return of the British Executive Commissioners and staff from the Centennial Exhibition, their respective reports were presented, by command of the Queen, to both houses of Parliament.

Prominent among these there will be found (in Vol. I. of the published Reports) one on "Machines and Tools for Working Metal, Wood, and Stone at the Philadelphia Exhibition," by John Anderson, LL.D., C.E., Superintendent General Machinery, Judge of Awards, and Chairman of the Group of Judges having in charge the examination of Group XXI. (Machines and Tools for Working Metal, Wood, and Stone).

From that portion of Dr. Anderson's report treating of American machinery we make the following extracts:

The display of machine-tools made by the United States was so vast that only the more salient points can be noticed in a brief report. It showed certainly that the past century has not been passed in idleness, and, judging by the enormous stride made by them during the past few years, it showed that they have been intelligent students of the best European authorities. It is true to say, however, that the Americans, as a rule, are not copyists; the inventing of clever devices and tools for saving labor seems to be their natural *forte*, and worthy of the old stock, probably quickened by the peculiarly favorable circumstances under which they live.

It was the display made in this section which most conspicuously brought out the enormous strength of

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America as a producing power. More than a hundred exhibitors had each a large exhibit that commanded the admiration of all who took the trouble to examine them in detail.

In this vast array were machines for all purposes, small arms, ammunition, sewing-machines, clocks, watches, and all the branches of machine-making and engineering, and almost all were finished in a style superior to that of any former Exhibition. . . .

The greatest display of machine-tools, however, and that which dwarfed all the others in the tool specialty, was made by the celebrated firm of W. Sellers & Co., of Philadelphia.

W. Sellers & Co., Philadelphia.

This collection of machine-tools was without a parallel in the history of Exhibitions, either for extent or money value, or for originality and mechanical perfection.

Altogether there were about forty distinct machines, most of them large, and many of them of gigantic proportions, but all characterized by extreme refinement to the minutest details. Besides, it was thoroughly national in its character, and pre-eminently worthy of the Centennial.

Steam-hammers.

A steam-hammer shown by this firm was remarkable for the elegance and originality shown in several of its details, in the form and arrangement of the hammer proper, for the manner in which the hammer-head is secured to the hammer, affording great convenience in fixing and unfixing. Also for novelty in the mode of working the steam-valve and several marked improvements in connection therewith.

One of the machines was for producing flat surfaces, and, although a new conception, was here developed into a practical tool for the engineer. Sir J.

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Whitworth was the first to develop the true surface-plate system, which has hitherto been arrived at by planing and scraping, depending on volition for the ultimate perfection of a true plane. In this new idea the true surface of a perfect table is transferred to other surfaces by moving the latter over a grinding instrument in the middle of and on the same true plane. The most important feature is this, that the surface to be made true may be of any degree of hardness, even chilled cast-iron or hard cast-steel, thus opening up a new field of endless application for slide-valves, and for many parts of tools and machines where extreme hardness is a virtue.

Lathes.

In lathes of all kinds this firm is remarkable for mathematical accuracy, and all were furnished with original devices, which enables a zealous workman to develop the produce of a lathe to its utmost capability, yet without physical effort.

By the introduction of an under V within the bed the shifting-head is always drawn to the same straight line, thus avoiding the necessity of a tight fit within the shear and its consequent disadvantages. Their system of feed-motion is admirable, a simple combination of disks whereby the feed-rate may be altered from one extreme to another, or to any intermediate point by a mere touch.

Planing machines.

Their planing machines are famous in Europe, and are now being copied in all countries. One of the largest ever made, which planes automatically in three directions, is now under construction at Philadelphia for a Russian arsenal. These planing machines are distinguished for directness in the transmission of power. The trammels, which have hitherto kept engineers to spur or bevel gear, are broken through;

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they employ the old gear only when it is the best for the purpose, but if not, they devise a new and special gear going straight to the point in whichever direction it may be. This is shown in several of their machines, including the planing, and naturally raised controversy among experts. The devices employed to give the feed-motions at the proper point, and to avoid a struggle between the open and cross belts at the reversing moment, are most ingenious, and were much admired by the judges.

One of the most striking features of the American section is the variety of special tools for all sorts of purposes. In this also they take the lead. One example was a lathe for brass work, employed in making the water-injector for steam boilers. Considered as a combination of clever devices to accomplish a definite object it was a fine tool. It enables an intelligent man to accomplish more work in turning, boring, screwing, or fitting than is possible in an ordinary slide-lathe, which is intended for general work. Besides, it is less dependent on the workman for accuracy.

Lathe for brass work.

It was the general opinion among engineers at the Centennial that this class of machinery will have to be more and more resorted to as competition intensifies, because it reduces cost of production and raises quality. Messrs. Sellers' gear-cutting machine is also well known in Europe. It is entirely and strikingly automatic. It receives its work and performs it to the end, shifting from one division to another until completed. No attendant workman being required meanwhile. Even the mathematical curves of the circular-cutting instrument, including the curve of clearance, are all predetermined and embodied in a machine irrespective of any future intelligence having

Gear-cutting machine.

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to be exercised in their production; still more, the curves are such, that as the cutters wear through use, the fresh tines presented at each sharpening are ever mathematically true as predetermined.

This example of the material embodiment of certain refined geometric ideas in one machine,—the faculty of foreknowledge by which it is capable of transmitting the same in perpetuity to another machine,—the gear cutter is remarkable. The automatic cutter former considered in connection with the automatic gear cutter requiring no attendant, one man being able to attend upon four machines, is suggestive. And this degree of mechanical culture in the gear cutter is the condition that all our tools have to be brought up to; man's intelligence designing and directing, while the iron slave performs the drudgery.

Heavy shearing machines.

A marked change is coming over the construction of heavy shearing machines. Usually the entire strain of the shearing action comes direct upon an eccentric, with all its accompanying friction and wear. In a series of grand machines shown by Messrs. Sellers, this inordinate pressure is distributed, by the intervention of a lever within the framing, thereby saving power and securing much greater endurance in the vital parts of the machine.

One of these machines, with a shear of nearly five feet, was employed in cutting thick plates, and upon an entirely new plan, which attracted much attention. It was automatic in its several movements, and so contrived that it cuts up to a definite point upon a line as previously determined, and there stops of itself.

This is one of the machines into which the direct style of gear has been introduced with great advantage both in first cost and ultimate economy.

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Two of the articles exhibited by Messrs. Sellers were English inventions, with the inventors' names put prominently forward.

Mr. Batho. Nut-shaping machine.

A nut-shaping machine by Mr. Batho was one of them. By a singularly simple, yet most ingenious conception, Mr. Batho has devised a system of synchronous instruments which act simultaneously upon each of the six sides, yet without coming into contact or interfering with each other. A score of nuts are strung upon a mandril, which automatically passes through a circle of cutters, either up or down, with a constant stream of oil, kept up by a circulating pump, which is part of the machine, and serves to maintain the cutters in good condition.

Mr. Ralph H. Tweddell. Hydraulic riveting apparatus.

The second English invention was the hydraulic riveting apparatus of Mr. Ralph H. Tweddell, which has already found admission into some of the best workshops of America.

This tool is a decided advance on all its predecessors. It is simple, it affords a controlled pressure, and acts with promptitude and certainty of action. And besides its portability it performs its work in perfect silence. Both machines have been modified for the better by the American makers, and both inventions seem to be highly appreciated by the engineers who examined them. The inventors' names being more familiar among the Americans than on this side of the Atlantic.

Rotary puddling machine.

The same firm exhibited a rotary puddling machine, which received much attention. The vessel was built up of wrought-iron, with water circulating arrangements, and lined in the usual manner. It worked at right angles to a furnace, the open end rubbing upon the side.

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An independent steam-engine was employed to work the vessel, which was perfectly under control to turn either way as desired, or to step backwards, or to advance close to the furnace side.

No luting was employed where the vessel touches the furnace, both surfaces being turned, and was reported to keep free, and fulfill all the necessary conditions. . . .

. . . It is also to be observed that American drilling machines are undergoing a new development. Spindles are now nearly balanced, the preponderance being on the side of the counterbalance, which is usually in the interior of the framing. With the counterbalanced spindle the drill does not drop in passing through, thus avoiding fracture of drill. Spindles are arranged for a quick, free movement into and out of the hole, the automatic or hand feed only coming into play when drilling commences. . .

Driving drilling machines.

A new idea is now prevalent in America in regard to the manner of driving drilling machines, which seems likely to alter their system of construction almost entirely. They find that with a given quantity of power, more work is done with a belt alone than with the usual system of wheel-gear intervening. . . . Accordingly, the belt, unaided, is superseding the gear system, in the best workshops, for all drilling where repetition is involved.

Sharpening drills.

Another important feature in their workshop economies is the manner of sharpening drills.

The drills are not held in the hand, but in an instrument which presents the drill to the grinder in a manner which ensures positive truth in the cutting edges, besides mathematical accuracy in the angles, thus rendering the drill more efficient, and affording

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more and better work than is practically attained by the rule of thumb system at the grindstone.

In the Exhibition there were shown several of such drill-grinding contrivances; that by W. Sellers & Co. was considered the best.

. . . Another point to be observed in passing, was the circumstance of machine tool makers being the constructors of the lighter kinds of mill-gearing for all descriptions of factories. This seems a good arrangement, because no class of machinists, from their training and knowledge of tool production, are more likely to give a tone and efficiency to this important branch of manufacture. The firm of Wm. Sellers & Co., for example, are great authorities in this class of work in the United States. One of the partners, having made the subject his specialty, has taken up the subject of transmission of power at the point where it was brought up to by the late Sir W. Fairbairn. . . .

Concluding remarks.

. . . Great Britain certainly can claim the credit of having been the birthplace of modern machine tools, and has done wonders in raising the mechanical standard of perfection, and her influence for good in the advance of civilization thereby is incalculable. But when we consider the enormously greater area of the American continent, it is a matter of vast importance that tools have taken such a hold of the American mind, which will influence the civilization of the Western world for ages to come, and will exercise a powerful effect, not only on that continent, but on Australia, China, and the world generally; this, therefore, has a profound significance which can scarcely be overrated. . .

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MACHINE TOOLS.

REVISED 1884.

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PREFACE

TO

EDITION OF 1883.

DURING the seven years that have intervened between the Centennial Exhibition and the publication of the present edition of the descriptive treatise on our machine tools, we have not only added many new tools to our list, but have made many important changes in those which we had previously made. We have found it necessary to rewrite the greater part of the book, and now call attention in particular to the description of our new form of self-acting slide-lathes, to the many improvements in punching and shearing machines, and to our patent drill-grinding machine, which enables us to produce a drill capable of doing more work at one grinding than by any other known method of sharpening. All parts of the work will, to those who are interested in the improvements introduced into labor-saving machine tools, repay careful perusal. To make the illustrations truly represent the form of our machines we have availed ourselves of the comparatively new process of phototype reproduction, thus giving the exact representation of the machines as taken by the photographic camera.

WILLIAM SELLERS & CO.

April 9, 1883.

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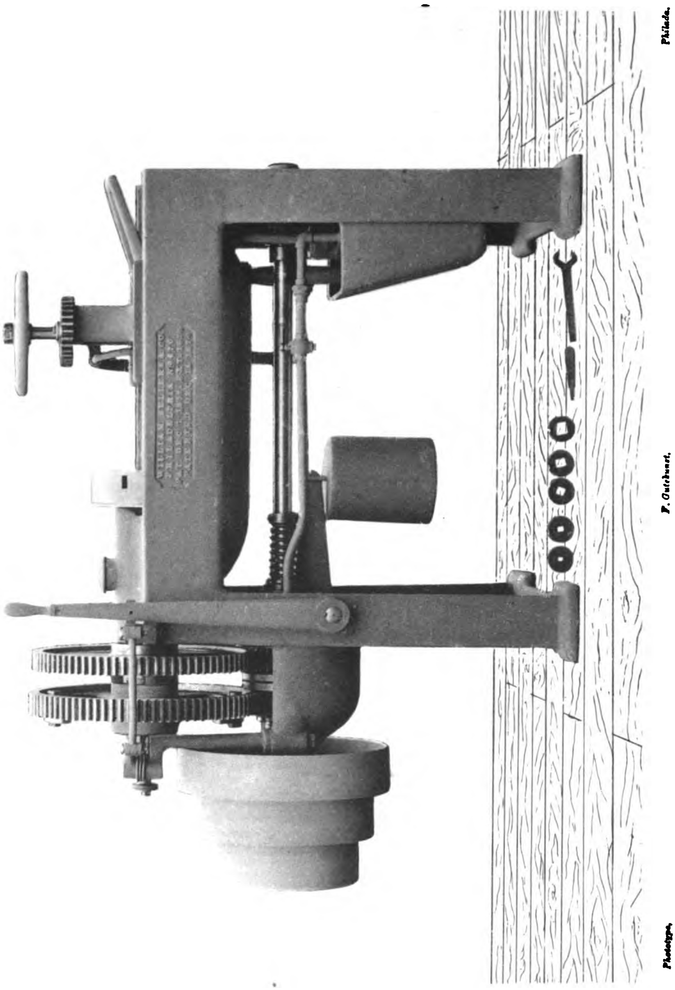
Fig. I.



1½-INCH PATENT BOLT AND NUT SCREWING MACHINE.

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PATENT BOLT AND NUT SCREWING MACHINE.

(*For Report of Judges, see page* xviii.)

With improved die-box, fitted with adjustable dies, to compensate for wear; automatic self-opening attachment, adjustable in length of bolt threaded; self-acting oil-feeder, for dies and taps; full set of taps, with tap-holders, for the range specified; over head shaft, pulleys and ball-and-socket hangers complete; wrought-iron work case hardened.

The advantages claimed for these machines over others in use are:

1st. The dies revolve and the bolt is stationary, which enables the workman to put in a fresh bolt without stopping the machine, and on long bolts is much more convenient than to revolve the bolt.

2d. The motion of the dies is always in one direction, and the bolt is cut at one operation; the dies open while they are revolving, consequently they leave no mark on the thread.

3d. The dies never run backward; the cutting edge will last much longer than when the motion of the die is reversed.

4th. The dies are adjustable, so as to compensate for wear.

5th. The dies can be changed without taking off any of the die-holding apparatus, and in less time than they can be changed in a common hand-screwing stock.

6th. The bolt-holder is arranged so as always to chuck the bolts in the centre of the dies, thus insuring correct work when the bolts come to be put in their places.

7th. The self-acting oil-feeder insures thorough lubrication of the dies, effectually prevents their heating, and is so arranged as to wash the chips out of the die-box.

8th. The automatic self-opening attachment insures uniformity in length of bolt threaded.

9th. Die-box is provided with four dies, equally spaced, insuring accurate work. Each pair of dies calliper the bolt while being cut, thus making the bolt round and to gauge.

10th. Is fitted for use as a nut-tapping machine, with automatic lubrication of the tap.

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Size of Machine.	Range of Cut.	No. of Taps sent with each.	Speed of Counter.	Size of Fast and Loose Pulleys.			
				Diam.	Face.		
					Loose.	Fast.	Loose.
¾″	¼″ to ¾″	8	200 rev's per min. in all cases.	12″	7″	4″	7″
1″	$\frac{5}{16}$″ to 1″	8		13″	7″	4″	7″
1½″	½″ to 1½″	8		14″	8″	4¼″	8″
2″	¾″ to 2″	8		19″	8″	4¼″	8″
2½″	1″ to 2½″	8		20″	8″	4¼″	8″
3″	1⅛″ to 3″	9		22″	8″	5″	8″
4″	1½″ to 4″	9		26″	8″	5″	8″

IN these machines the bolts are cut as with solid dies, at one operation,—*i.e.*, with once going over, but the dies open under cut when the work is done, and in releasing the bolt remove all trace of the chip made by the cutting tools. The specification on page 5 clearly expresses the advantages of the machine.

Index on back of driving wheel.

On the back of the large driving wheel is an index or pointer, which must be set to numbers given on a card sent with each machine. When so set, the bolt will fit a nut of corresponding size cut with the tap sent with machine.

Adjustment of size of bolt.

An adjustment of the index, one way or the other, will cause the bolt cut to be larger or smaller, thus permitting the thread to be adapted to the use required of it, and also permitting an adjustment of dies to compensate for wear.

Some important improvements have recently been made in this machine, viz.: a slight change in the mode of driving has enabled us to run them at a higher speed, and a novel oil-feeding device supplies the oil to the back of the dies, whence flowing out, it thoroughly lubricates the cutters and the bolt end, and

Oil-feeder.

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washes out the chips as they are cut from the bolt. A regulating cock in the feed-pipe directs the oil either to the dies as above stated, or to the tap when the machine is used as a nut tapper.

Adjustable stop-motion. Added to this a convenient adjustable stop-motion is provided whereby the dies are opened automatically when a given length of thread has been cut.

Four dies in the die-box. We construct our bolt cutters with four dies in the die-box. These dies are equally spaced, and each pair has one die diametrically opposite to the other one of the pair. This arrangement insures accurate work, inasmuch as the opposite dies calliper the bolt while being cut, thus making the bolt round and to gauge.

Use abroad. These improvements have added greatly to the value of this important tool, which is made and used extensively in England and on the Continent, and is believed to have no equal in durability and efficiency.

V threads. These machines are fitted with dies for cutting V threads only, and, when not otherwise specified, we furnish taps and dies corresponding with the American standard, which was recommended for general adoption by the *Franklin Institute of the State of Pennsylvania for the Promotion of the Mechanic Arts, at a meeting held December* 15, 1864.

American standard.

Wood screws and square threads. We can adapt dies for cutting coarse-threaded wood or "lag" screws, and so also dies for cutting square threads; in case of the latter, it is advisable to make the cut with more than once going over, to produce smooth work. Unless specially ordered to the contrary, our machines are always adjusted to cutting threads to standard diameters, and if over-sized iron is used in bolts, it should be swaged down on part where screw is to be cut to the proper size.

Cuts to standard diameter.

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Counter-shaft. The counter-shafts of our bolt cutters are made with two loose pulleys, one on each side of a fast one, so that open and cross belts can be used to run the machine backwards as well as forwards. This running backwards is only of use in recutting dies, or cutting left-handed screws. **Recutting dies.** To sharpen the dies, they must be softened, and then recut with hobs, which we make for this purpose, but which are not included in the price of the machine, inasmuch as when more than one machine is in the same shop one set of hobs and collars will do for them all. **Hobs for re-cutting.** **Collars sent with hobs.** The hobs are guided in recutting dies by collars fitting in a hollow sleeve, which guide a prolongation of one end of the hob, while the other end is steadied in the clamp for holding the bolts to be cut. This insures perfect concentricity to the dies. It must be borne in mind that in the use of bolt cutters, oil should be freely used upon the work. This on the new style machine is accomplished by the automatic feed; and the oil used should be *animal*, not from *coal*. **Use animal oil only.** The commonest lard or fish oil will answer a good purpose.

With each machine we send full printed directions for setting the dies and for repairing them. All parts of our bolt machines are made to gauge, and dies fitted to one machine can be used in any other machine of the same size of our make. We can therefore make new dies of any required thread to be used in any one of these machines, without having the machine in which they are to be used to fit them to. **Can furnish new dies.**

This is of great importance in the case of special dies being needed for any purpose, when the user of the machine has no convenience for producing new dies. The sharpening or recutting of the dies is readily done by any mechanic, but either blank dies or finished

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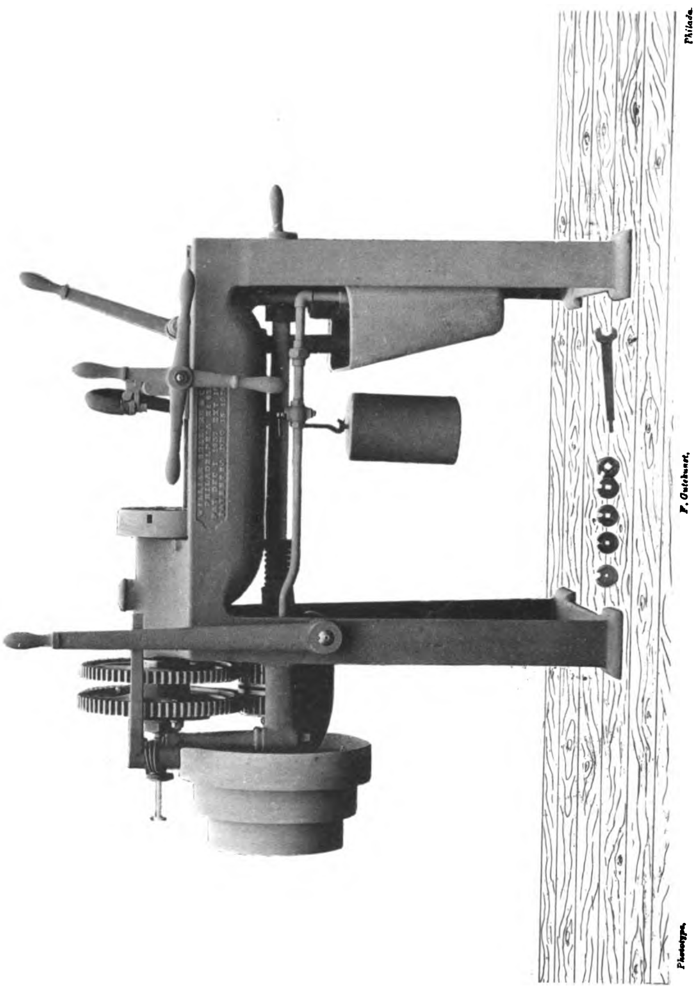
FIG. 2.



¾-INCH PATENT BOLT AND NUT SCREWING MACHINE.

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dies can be readily furnished to those who do not desire to make them.

Our 1″ and $\frac{3}{4}$″ bolt cutters differ from the larger sizes in the clamp vice for holding the bolt.

Fig. 2 (page 10) represents our $\frac{3}{4}$″ size of machine, intended to cut from $\frac{1}{4}$″ to $\frac{3}{4}$″. This size is admirably adapted to cut set-screws and small bolts. In using it with set-screws it is well to arrange a socket-wrench to be clamped in the bolt holder, the head of the set-screw fitting the socket loosely. By the use of such a device the bolts can be set and removed more rapidly than when each one has to be clamped in the bolt holder. This machine has been run at the rate of 2800 bolts in ten hours on $\frac{3}{4}$″ bolts threaded two inches in length, but this rate is not economical, inasmuch as the excessive speed is too hard on the dies. We recommend the counter-shaft being speeded to 200 revolutions per minute, the speed on the dies of the fastest and the slowest speeds will then be at the rate of 12 feet circumferential motion per minute on $\frac{3}{4}$″ and on $\frac{3}{8}$″ bolts. The $\frac{3}{4}$″ bolt having 10 threads per inch, will be threaded at the rate of six inches in length of bolt per minute, and if the thread be $1\frac{1}{2}$″ long, at the rate of four per minute, exclusive of the time consumed in putting in and taking out the bolts; one man can at this rate very well run two machines cutting from 1500 to 1800 $\frac{3}{4}$″ bolts on each machine.

How to hold set-screws.

Speed of cut.

Number of bolts it will cut.

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THE AMERICAN STANDARD SCREW THREAD.

THIS form of screw thread for ordinary bolt and nut use, to which allusion has been made on page 7, grew out of an investigation of this subject made by Mr. William Sellers, and presented to the Franklin Institute of the State of Pennsylvania in a paper read by him April 21, 1864. In this, after commenting on the importance of a uniform system of screw threads and nuts, he urges the desirability of some system that would permit its expression in formulæ, and that could be reproduced at any time as original with ordinary tools and instruments of measurement. He objected to the form of thread known as the Whitworth standard, and says:

"The form of thread adopted by the English engineers is one with flat sides, at an angle to each other of 55°, with a rounded top and bottom. The proportions for the rounded top and bottom are obtained by dividing the depth of a sharp thread having sides at an angle of 55° into six equal parts, and within the lines formed by the sides of the thread and the top and bottom dividing lines, inscribing a circle, which determines the form of top and bottom of thread. Judging from the practice of this country, the English form of thread has not met with the same favor that has been accorded to their pitches. Its advantages over the sharp thread are: increased strength to the screw from the absence of acute corners, and the greater security from accidental injury which the rounded top possesses. Its objectionable features are, first, that the angle of 55° is a difficult one to verify; it is probable no gauges to this angle, made independently of each other and without special tools, would correspond with sufficient accuracy. Secondly, the curve at the top and bottom of the thread of the screw will not fit the corresponding curve in the nut, and the wearing surface on the thread will be thus reduced to the straight sides merely. It is not to be inferred from this that these curves cannot be made

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to fit, but only that the difficulties in producing contact are so much increased by the peculiar form, that in practice it will not be accomplished. Thirdly, the increased cost and complication of cutting tools required to form this kind of thread in a lathe, it being requisite that this tool shall have at least three cutting-sides, in order to form the round top between two of them. The English practice for small work is to rough out in a slide-lathe with a single-point tool having sides of the proper angle, and finish in a hand-lathe with a comb-chaser, which has been dressed to the proper form upon a hob kept for that purpose, requiring three kinds of cutters and two lathes to perform what with our practice requires but one cutter and one lathe. On large work the screw is finished in the slide lathe, with a chasing tool dressed to the proper form upon a hob; and as these hobs are necessarily the standards of form until worn out, it is fair to suppose the shape must be undergoing a continual change."

He then continues:

"The necessity of guarding the edge of the thread from accidental injury becomes more and more apparent as the size of the bolt is increased, and we have recognized this by finishing such bolts with a small flat upon the top of the thread; but no plan has been proposed for general adoption upon all screws, nor have any proportions been suggested where a flat is desired, or where from the size of the bolt it would seem to be necessary. As it is very desirable that some uniform rule should be observed in the formation of all threads, and as the sharp top is objectionable upon large screws, this form must be abandoned if we would accomplish our object. It being conceded that the flat angular sides are necessary, we have only to choose between the rounded and flat top; and, having examined the former, it only remains to notice whether the flat will be found free from the objections urged against the round. As the sides of the thread are the only parts requiring to be fitted, and as these are of the same shape as the sharp thread, the one will be as easily made as the other. The width of the flat top will

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be determined by the depth to which the thread is cut, so that the same tool can be used in both cases. The flat on the top of the thread being required to protect it from injury, it is evident a similar shape at the bottom would give increased strength to the bolt as well as improve its appearance. To give this form requires only that the point of the cutting tool shall be taken off, and then it is evident this thread can be cut in a lathe with the same tool and in the same manner as the sharp thread. The width of flat in the bottom of thread being dependent upon the amount taken off the point of the tool, it becomes necessary not only to determine what this amount shall be, but also to provide a means of measuring it.

* * * * * * * *

"The angle of the proposed thread is fixed at 60°, the same as the sharp thread, it being more readily obtained than 55°, and more in accordance with the general practice in this country. Divide the pitch, or, which is the same thing, the side of the thread, into eight equal parts, take off one part from the top and fill in one part in the bottom of the thread, then the flat top and bottom will equal one-eighth of the pitch, the wearing surface will be three-quarters of the pitch, and the diameter of screw at bottom of the thread will be expressed by the formula

$$\text{diam.} - \frac{1.299}{\text{per in.}}.$$

These proportions will give the depth of the thread almost precisely the same as the English, and as the wearing surface on all screws will be confined practically to the flat sides, we shall find that upon the proposed plan this will be 36 per cent. greater than on the English."

* * * * * * * *

A system of uniform dimensions for bolt heads and nuts being intimately connected with the subject discussed, he believed that a convenient formula that would express the required size would go far towards inducing a uniform practice, and with this view he submitted formulæ and tables for screw threads and nuts which he

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offered for the acceptance of our engineers; thinking that should they meet the approval and be adopted by any considerable portion of the profession, there was every reason to believe they would soon be applied universally.

At the meeting at which this paper was read it was resolved that a special committee be appointed to investigate the question of the proper system of screw threads, bolt heads, and nuts, to be recommended by the Institute for general adoption by American engineers.

The committee handed in their final report at the meeting of the Institute held December 15, 1864, in which they discuss the form proposed by Mr. William Sellers, also the other features of his system, and offered a resolution which embodied his views, as follows:

"*Resolved*, That the Franklin Institute of the State of Pennsylvania recommend, for general adoption by American engineers, the following forms and proportions for screw threads, bolt heads, and nuts, viz.:

"That screw threads shall be formed with straight sides at an angle to each other of 60°, having a flat surface at the top and bottom equal to one-eighth of the pitch. The pitches shall be as follows, viz.:

Diameter of bolt...	$\frac{1}{4}$	$\frac{5}{16}$	$\frac{3}{8}$	$\frac{7}{16}$	$\frac{1}{2}$	$\frac{9}{16}$	$\frac{5}{8}$	$\frac{3}{4}$	$\frac{7}{8}$	1	$1\frac{1}{8}$	$1\frac{1}{4}$	$1\frac{3}{8}$	$1\frac{1}{2}$	$1\frac{5}{8}$	$1\frac{3}{4}$	$1\frac{7}{8}$
No. threads per in.	20	18	16	14	13	12	11	10	9	8	7	7	6	6	$5\frac{1}{2}$	5	5
Diameter of bolt...	2	$2\frac{1}{4}$	$2\frac{1}{2}$	$2\frac{3}{4}$	3	$3\frac{1}{4}$	$3\frac{1}{2}$	$3\frac{3}{4}$	4	$4\frac{1}{4}$	$4\frac{1}{2}$	$4\frac{3}{4}$	5	$5\frac{1}{4}$	$5\frac{1}{2}$	$5\frac{3}{4}$	6
No. threads per in.	$4\frac{1}{2}$	$4\frac{1}{2}$	4	4	$3\frac{1}{2}$	$3\frac{1}{2}$	$3\frac{1}{4}$	3	3	$2\frac{7}{8}$	$2\frac{3}{4}$	$2\frac{5}{8}$	$2\frac{1}{2}$	$2\frac{1}{2}$	$2\frac{3}{8}$	$2\frac{3}{8}$	$2\frac{1}{4}$

"The distance between the parallel sides of a bolt head and nut, for a rough bolt, shall be equal to one and a half diameters of the bolt plus one-eighth of an inch. The thickness of the heads for a rough bolt shall be equal to one-half the distance between its parallel sides. The thickness of the nut shall be equal to the

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diameter of the bolt. The thickness of the head for a finished bolt shall be equal to the thickness of the nut. The distance between the parallel sides of a bolt head and nut, and the thickness of the nut, shall be one-sixteenth of an inch less for finished work than for rough.

"*Resolved*, That a copy of these resolutions be forwarded to the Quartermaster-General, Chief of the Bureau of Steam Engineering of the Navy, and the Chiefs of Ordnance for the Army and Navy, and Chiefs of the Engineer and Military R. R. Corps, and the Supt. and M. M. of R. R. Companies, requesting them to use their influence to promote the adoption of a uniform system of screw threads, bolt heads, and nuts by requiring all builders under any new contracts to conform to the proportions recommended.

"*Resolved*, That a copy of these resolutions be also sent to all Mechanical and Engineering Associations or Institutes, and the principal machine and engine shops in the country, with a request that they will use their influence in the proposed system.

"*Resolved*, That this Committee be now discharged.

"WM. B. BEMENT, *Firm of Bement & Dougherty.*
"C. T. PARRY, *Supt. Baldwin's Locomotive Works.*
"J. VAUGHAN MERRICK, *Firm of Merrick & Sons.*
"JOHN H. TOWNE, *Firm of I. P. Morris, Towne & Co.*
"COLEMAN SELLERS, *Eng. Wm. Sellers & Co.*
"B. H. BARTOL, *Supt. Southwark Foundry.*
"E. LONGSTRETH, *Foreman Baldwin's Locomotive Works.*
"JAMES MOORE, *Firm of Matthews & Moore.*
"WM. SELLERS, *Firm of Wm. Sellers & Co.*
"ALGERNON ROBERTS, *of the Pencoyd Iron Works.*"

After the acceptance of this report and the adoption of its resolutions, many of the leading railroads and machine makers accepted this standard, known as the Franklin Institute standard.

On May 15, 1868, Mr. B. F. Isherwood, Chief of Bureau of Steam Engineering, submitted to the Hon. Gideon Welles, Secre-

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tary of the Navy, the report of a Board to recommend a standard gauge for bolts, nuts, and screw threads for the United States Navy. This report, which has been published for use of the navy yards and naval steamers, reviews the subject in a thorough and practical manner. It considers the general practice of the leading workshops of the country, and unhesitatingly indorses what it calls the system of Mr. Sellers. Its recapitulation expresses the formulæ thus:

Angle of thread, 60°.

Let

D = nominal diameter of bolt.
p = pitch of thread.
n = number of threads per inch.
H = depth of nut.
d_n = short diameter of hexagonal or square nut.
d = effective diameter of bolt = diameter under root of thread.
s = depth of thread.
h = depth of head.
d_h = short diameter of head.

Then—

$$p = 0{\cdot}24\sqrt{D + 0.625} - 0.175, \text{ or}$$
$$p = .06\sqrt{16\,D + 10} - .175.$$
$$n \text{ [number of threads per inch]} = \frac{1}{p}.$$
$$s = 0.65\,p.$$
$$d = D - 2\,s = D - 1.3\,p.$$
$$H = D.$$
$$d_n = \tfrac{3}{2}\,D + \tfrac{1}{8}''.$$
$$d_h = \tfrac{3}{2}\,D + \tfrac{1}{8}''.$$
$$h = \tfrac{3}{4}\,D + \tfrac{1}{16}.$$

It then gives a table of screw threads the same as that recom-

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mended by the Franklin Institute, with the one difference and that regarding the size of finished or unfinished bolt heads and nuts. The navy report makes no difference in the size of either —that is, for finished work the forgings must be made larger than for rough; their idea being to use the same wrench on either black or finished work. In reference to their tables they say:— "The only instance where the values in the table differ from those given by the formulæ is in the number of threads per inch, which is so far modified as to use the nearest convenient aliquot part of a unit, so as to avoid, as far as practicable, troublesome combinations in the gear of screw-cutting machines." Then—

"In concluding this report the Board desires to say, that in recommending the system of Mr. Sellers as a standard for the navy, it has been governed by considerations other than those suggested by the merits inherent in the system itself.

"Fully realizing the importance of entire uniformity of practice in private establishments as well as in the navy, we were naturally desirous to select a system which, while meeting all the essential requirements of a system, would be most likely to be generally acquiesced in and adopted.

"So far as we have been able to confer with engineers and manufacturers, either personally or by letter, we have heard but one opinion expressed in regard to the importance of uniformity of practice. Many have already adopted the Sellers pitch; others are gradually adopting it; while others still express their willingness to adopt it. A majority, we confidently believe, are now willing to adopt Sellers' form of thread also, provided it be made the standard."

This report was signed by

THEO. ZELLER, *Chief Engineer U. S. Navy.*

ALEXANDER HENDERSON, *Chief Engineer U. S. Navy.*

D. M. GREENE, *First Ass't Engineer U. S. Navy.*

Chief Engineer B. F. ISHERWOOD, U.S.N., *Chief of Bureau of Steam Engineering.*

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In answer to the letter of Mr. Isherwood, accompanying the report, the Secretary of the Navy writes:

"NAVY DEPARTMENT, May 16, 1868.

"SIR,—The standard for the dimensions of bolts and nuts, as determined by the Board, is, upon your recommendation, authorized for the naval service.

"(Signed) GIDEON WELLES,

"*Secretary of the Navy.*

"Chief Engineer B. F. ISHERWOOD, U.S.N., *Chief of the Bureau of Steam Engineering.*"

The system was also introduced in other departments; and of the many hundred bolt cutters made by us since the introduction of the system, very few have been fitted with any other screw thread; and it has met with such general favor that it can safely be considered as the American Standard.

WHAT IS COMPRISED IN THE TERM "STANDARD."

Since the publication of our edition of 1877 the manufacture of standard taps and dies and standard bolts and nuts has very much increased. To enable our readers to form a correct idea of just what this standard is, we now publish the table used by ourselves, which table (page 22) gives the diameter of the bolt, the number of threads per inch, the diameter at the root of the thread, and the width of the flat top and bottom of the thread. When we say diameter of the bolt we mean actual diameter; that is, the inch bolt must be one inch diameter, not more or less, it must measure .837 of an inch at the root of the thread, the angle of the sides of the threads to each other must be 60°, and the width of flat top and bottom of the thread will be .0156 of an inch. The actual diameter is an essential part of the Standard

Table of screw-threads.

Exact diameter essential.

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System. Any deviation from this diameter is a deviation from the standard. Diameter is as essential to standard as is pitch or shape of thread. Bolts and nuts cannot be made so as to interchange one with another if the diameters are not the same. We dwell upon this because makers of taps and dies are asked to sell oversized taps to accommodate the cutting of oversized iron, on the plea that trade bolt-iron runs oversize, and it is waste of material and hard on the dies to cut large iron down to the named diameter. All machine-shop practice requires that the turned bolt, as well as black ones, must be threaded. The drills, reamers, and taps for finished bolts are made to actual named diameter, not to any oversize, so that two sets of taps and dies are required—one for black and the other for finished bolts—if this difference in size is persisted in. The oversize come into use with those who use or make black bolts only, and who encourage the sale of oversizes of iron by not seeking iron of the proper size, and who thus, so far as this work is concerned, destroy the interchangeable element of the system.

Oversize taps

Rolling iron to size.

Rolling-mills will furnish iron to size when approximately exact size is made obligatory, and it has been demonstrated that the saving in weight by the purchase of correct diameter of rounds for bolts more than pays for the little trouble of careful inspection.

INSPECTING STANDARD SCREW-THREADS.

The dies in our bolt-cutters are threaded by means of hobs, which are as near to the correct conditions of the standard thread as can be made. To test the correctness of the thread formed in the dies it is only

To test the thread.

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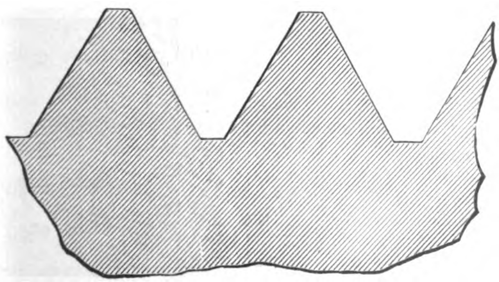
necessary to turn a piece of iron to the exact diameter of the bolt to be cut, and turn one end of the rod for a short distance down to the tabular diameter at the root of the thread: say, in the example already cited on page 19, for an inch bolt the iron rod should be made one inch in diameter exactly, and one end of the rod, say for half an inch in length, should be turned to .873 of an inch in diameter. Now setting the dies down until they just mark this small end without cutting it, and proceeding to cut the body of the rod, the thread produced should show to the eye an equal amount of flat top and bottom of the thread, and the outside of the turned bolt should not be reduced by the cutting of the thread.

Assuming that the threads of the bolt so cut are at the proper angle of side, that is, 60°, the thread cut will be standard, and a nut tapped with the tap coinciding with this thread should fit the bolt thus cut.

Testing taps. Taps wear from use, and they should be rejected as soon as they are too much worn to fit the standard diameter of bolt. It is very important to keep the dies set to the right diameter, and the tap may begin by cutting a free fit to the lot of nuts being cut, and used until the fit is as close as is consistent with use.



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Proportions for Screw Threads.

Diameter of Screw.	Threads per Inch.	Diameter at Root of Thread.	Width of Flat.	Diameter of Screw.	Threads per Inch.	Diameter at Root of Thread.	Width of Flat.
$\frac{1}{4}$	20	.185	.0062	2	$4\frac{1}{2}$	1.712	.0277
$\frac{5}{16}$	18	.240	.0074	$2\frac{1}{4}$	$4\frac{1}{2}$	1.962	.0277
$\frac{3}{8}$	16	.294	.0078	$2\frac{1}{2}$	4	2.176	.0312
$\frac{7}{16}$	14	.344	.0089	$2\frac{3}{4}$	4	2.426	.0312
$\frac{1}{2}$	13	.400	.0096	3	$3\frac{1}{2}$	2.629	.0357
$\frac{9}{16}$	12	.454	.0104	$3\frac{1}{4}$	$3\frac{1}{2}$	2.879	.0357
$\frac{5}{8}$	11	.507	.0113	$3\frac{1}{2}$	$3\frac{1}{4}$	3.100	.0384
$\frac{3}{4}$	10	.620	.0125	$3\frac{3}{4}$	3	3.317	.0413
$\frac{7}{8}$	9	.731	.0138	4	3	3.567	.0413
1	8	.837	.0156	$4\frac{1}{4}$	$2\frac{7}{8}$	3.798	.0435
$1\frac{1}{8}$	7	.940	.0178	$4\frac{1}{2}$	$2\frac{3}{4}$	4.028	.0454
$1\frac{1}{4}$	7	1.065	.0178	$4\frac{3}{4}$	$2\frac{5}{8}$	4.256	.0476
$1\frac{3}{8}$	6	1.160	.0208	5	$2\frac{1}{2}$	4.480	.0500
$1\frac{1}{2}$	6	1.284	.0208	$5\frac{1}{4}$	$2\frac{1}{2}$	4.730	.0500
$1\frac{5}{8}$	$5\frac{1}{2}$	1.389	.0227	$5\frac{1}{2}$	$2\frac{3}{8}$	4.953	.0526
$1\frac{3}{4}$	5	1.491	.0250	$5\frac{3}{4}$	$2\frac{3}{8}$	5.203	.0526
$1\frac{7}{8}$	5	1.616	.0250	6	$2\frac{1}{4}$	5.423	.0555

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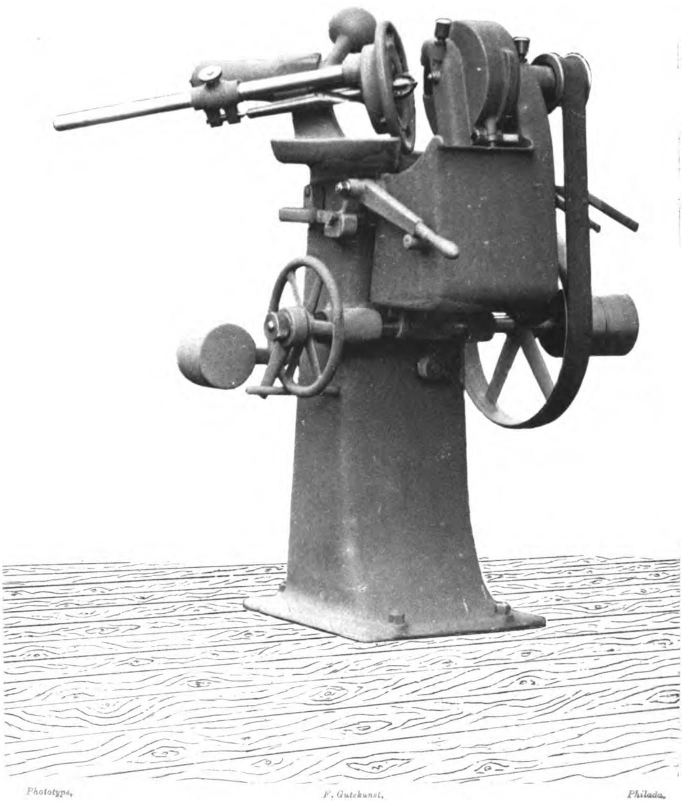
FIG. 3.



Phototype, F. Gutekunst, Philada.

DRILL GRINDING MACHINE.

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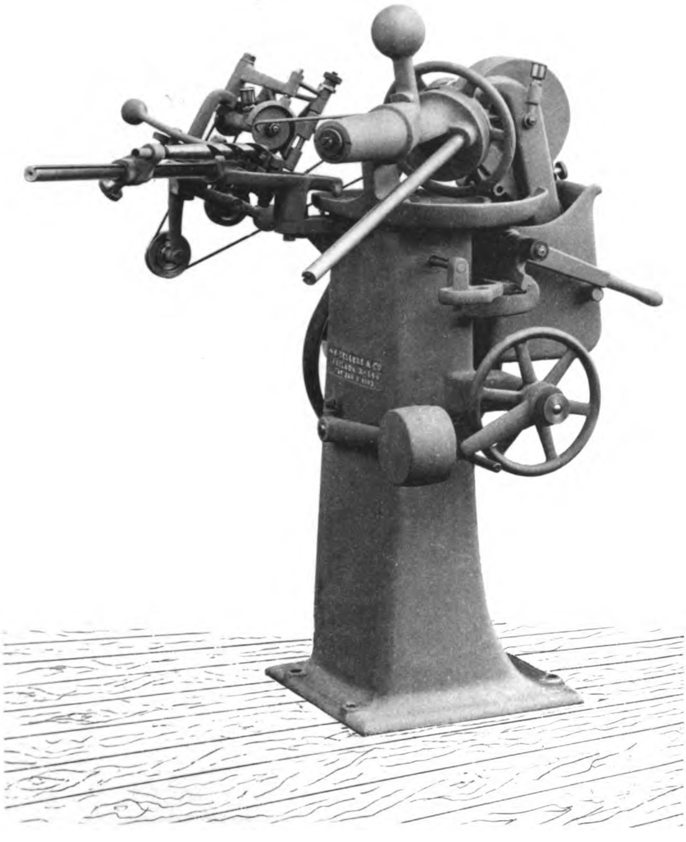
FIG. 3A.



PHOTOTYPE F. GUTEKUNST PHILAD'A.

DRILL GRINDING MACHINE, WITH POINTING ATTACHMENT.

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DRILL-GRINDING MACHINE.

DRILLS of all kinds, either flat or twist, do more or less work, good or bad work, in proportion to the skill expended in forming and shaping them. It can be shown just what shape the lip of a drill should have to enable it to do the best work; yet it is impossible to obtain this shape in hand-ground drills; while the drill grinding machines heretofore made yield scarcely an approximation to this shape. In our own experience, the difference between approximate and correct shape means great difference in the amount of work done.

Drills cannot be ground correctly by hand.

To drill true holes of uniform diameter and the closest approximation to the size of the drill, it is necessary that the two cutting edges of the lips of the drill should be of precisely the same length, and at the same angle with the axis of the drill; and to obtain the greatest drilling effect it is requisite that the backing or clearance of the two lips should conform as closely as possible near to the cutting edges, to the shape of the bottom of the hole produced by the drill, so as to give the greatest strength and support to the cutting edges, yet insuring sufficient clearance to enable the drill to cut freely without binding. As the shape of the bottom of the hole is usually a right cone, with the apex truncated by the point of the drill, it will be evident that the best shape for the end of the lips of the drill will be that of the surface of a similar cone having its axis sufficiently eccentric to the axis of the drill

What shape is needed.

Shape of the bottom of the drilled hole.

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to give the proper clearance to the edge. It is not necessary for the clearance to be the same over the whole length of the cutting edges; it should be slightly greater near to the centre, where the angular velocity of the drill is less.

Clearance near to centre.

We can understand what will be the proper clearance, and how it can be obtained, if we, in the first place, suppose a hollow right cone to be revolving about a horizontal axis, with its interior surface provided with some abrading substance, and that the lips of the drill are inserted into this cone in such a manner that the axis of the drill coincides with the axis of the cone. In such case it will be evident that the drill ground by the abrading cone will be shaped to a right cone,—that is, to the shape of the conical surface of the hollow cone,—but would not have the proper shape for cutting, as the centre of the drill would be shaped to a point, which could only enter the work to be drilled by punching or abrading, while the lips back of the edge of the drill would have no clearance whatever, and hence the drill would rub without cutting. If now, on the other hand, we suppose the edge of the drill to be horizontal, and that we move the drill away from the axis of the cone, and at the same time we lower the drill so that the cutting edge will be slightly below the centre of the cone, and that we present the drill to the abrading surface in this position, the back of the drill-lip will be ground away first, until the abrading surface touches the cutting edge of the drill. If the drill is now withdrawn and turned half around, and the other lip presented in the same position, it will result in each lip being ground to the shape of a right cone, and the point of the drill will be convex, like the point of a bow-drill formed for cutting in both

Correct shape.

Conical and without clearance.

How to give clearance.

Point formed by intersection of the cones.

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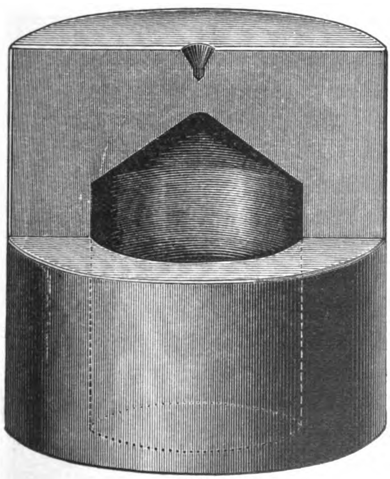
directions (being formed by the intersection of the two cones forming each lip), thus giving the best possible shape to the drill-point, and the clearance at the cutting edges will be exactly adapted to the bottom of the hole to be produced by the drill. The distance that the centre of the drill must be moved away from the apex of the cone depends on the thickness of the central part of the drill. To avoid excessive clearance on the outside of the drill-lip, it is found advantageous in practice to reduce the included angle of the hollow cone, so that the radius of the cone, where it touches the outside of the drill-lip, is but little greater than the radius of the largest drill the machine is intended to grind.

Thickness of metal at centre of drill.

Drills ground in the ordinary manner appear to have less clearance than do those ground in the manner just described, while in fact they have more. That this is the case may be readily shown by drilling a hole part

Appear to have less clearance.

Fig. 4.



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way through a piece of iron with the drill to be examined, and then planing a notch out of this template down to the centre of the hole that has been drilled, as is shown in Fig. 4. If the drill is again inserted and turned back and forth, its true clearance can be estimated or measured if desired. With such a template, a drill ground on our machine, which produces a shape similar to that above described, will be found to have as little clearance back of the cutting edge and close to it as is essential for good free work, while the more rapid falling off or the increased clearance beyond this is a matter of no moment so long as sufficient metal is retained at the heel to support the cutting edge. The seeming greater clearance is due to the falling off as we recede from the edge, which, as before stated, does not affect the clearance at the cutting edge.

Template for measuring the clearance.

To obtain the proper shape it is necessary that the axis of the drill shall not be coincident with or parallel to the axis of the cone to which it is ground, but should be as shown in Figs. 5 and 6. In these the hollow cone to which the drill end is to conform is shown by dotted lines in conical form: x, x, being the axis of drill A, and y, y, the axis of the cone. Fig. 5 shows the end surface of one lip of the drill at a, coinciding with the inner surface of the cone. Fig. 6 is the drill and the cone to which it is ground, as seen at right angles to the view given in Fig. 5, and shows the lowering of the centre of the drill below the axis of the cone to which it is ground. In this case, as the axis of the drill is not coincident with or parallel to the axis of the cone to which it is ground, it follows that the clearance of the drill-lip will increase slightly from the outside corner of the cutting edge to

Axis of the drill and the cone.

Most clearance near to the centre of the drill.

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FIG. 5.

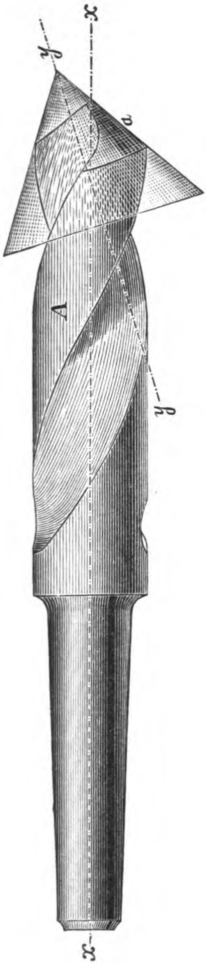
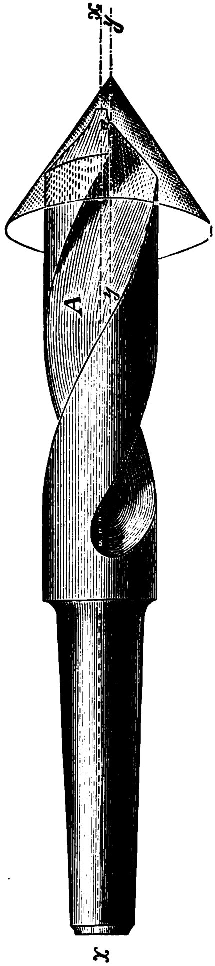


FIG. 6.



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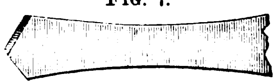
the point of the drill, as is indicated in Fig. 5. The shape of the end of the drill-lip will be part of the surface of a right cone, the axis of which will be coincident to that of the cone to which it is ground. To produce this shape of drill-lip in practice, it is not necessary to grind in the manner just described; that is, by holding the drill against a conical abrading-wheel, which revolves. A flat surface, tangent to the theoretical cone required, will grind the same shape if the drill be made to swing about the axis of the cone.

Same shape on a flat grinding-wheel.

Our new drill-grinding machine.

Our new drill-grinding machine is constructed on this principle. It grinds drills to the theoretically correct shape, and has the great advantage of being simple in construction, not liable to get out of order, and is inexpensive. It requires no outfit of expensive chucks to hold peculiar shapes of drills, and it does not require a skilled workman to operate it. It will grind with equal facility twist, fly, chuck, or any other kind of double-lip drill. Lathe-drills for roughing out holes, often made with the faulty shape shown in Fig. 7, are as readily dressed to equal length of cutting edge as the most improved form of drill with parallel sides. To this new machine we call especial attention, believing that any one who examines its merits will be impressed with its advantages and its utility.

Fig. 7.



Drill-pointing device.

We have recently added to this very efficient drill-grinding machine a device for pointing the drill, to which we call special attention. On page 6 we have dwelt on the character of the point of the drill ground on our machine, showing that the point pro-

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duced is somewhat like the double-cutting edge of a bow drill intended to cut in either direction of rotation; but at the best, this part of the drill, made even in the manner stated, has a scraping rather than a cutting edge, and the less angle there is given to the end of the drill the less able is this centre part to cut, and when the drill-end is made very flat it amounts to a rubbing without much cutting action. Sometimes the great friction of the point heats the metal and draws the temper of the drill in the centre. It is customary with some workmen to grind the point of the drill by hand, so as to lessen the length of the scraping edge; this requires great skill, and is not always attended with good results, as the drill is apt to be thrown out of centre.

Kind of point made by drill-grinder.

Grinding point by hand.

The power required to feed a drill is largely influenced by the length of the scraping edge of the drill-point. Our device enables this edge to be diminished to any required length, with a certainty of the point left being central, and without in the slightest degree diminishing the strength of the cutting-lips, which are as well supported as when the drill is not so pointed. Our system of pointing is by means of grooves on each side of the body of the drill, these grooves being at an angle to the cutting edges or lips of the drill and also at an angle to the axis of the drill. The grooves are deepest at the point of the drill, and rapidly grow shallower as they extend up the drill. The width of the grooves is proportioned to the diameter of the drill, being very narrow in small drills and wider in large drills. In this part of the machine, as in all other parts, there is nothing left for the skill of the workman. In clamping the drill to place in the pointing mechanism, the drill

Power required to feed a drill.

Character of the point produced.

Drill-point automatic.

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itself sets the stone that does the pointing to the obliquity that will give the required width of groove for that size of drill. All kinds of drills are held in the same manner and are guided by their cutting edges or lips, as in the case of the lip-grinding. Drills properly ground and pointed not only drill to size with the least power, but if they are also straight in the body, that is, run true, they wear the drill-press less than if they are out of truth, either in the length of the lips or in the body of the drill. Thus a straight, properly-sharpened drill used in a radial drill-press, the arm of which is not clamped to place, but free to vibrate, will not cause the arm to move. If, on the other hand, the arm does move while drilling, it is proof that the drill is either crooked in the body or that there is some fault in the length or the angle of the lips of the drill. Holding or trying to hold the arm firmly so as to resist this tendency, brings a strain on the drill-spindle and causes a wear of the bearings of the spindle; so that well-ground and straight drills not only do more and better work than those that are faulty in these respects, and are therefore economical, but the economy extends also to the press or machine in which they are used.

The effect of crooked drills.

Economy in use of well-ground drills.

On the following pages we give a full description of this new drill-grinding and pointing machine, with directions for operating in full, on pages 28 and 41. The handling is simple in the extreme. Its resultant work is perfect, and the very few precautions given on page 42 point out what must be attended to to keep the machine in working order.

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WILLIAM SELLERS & CO.'S PATENT DRILL-GRINDING MACHINE.

1st. Holds in the same chuck and in precisely the same manner all kinds of drills, either flat or twist, from one-quarter inch in diameter up to two inches, without requiring any bushings.

2d. It grinds the proper amount of clearance to every part of the cutting edge of the lips. This is theoretically correct on a small drill as well as on a large one.

3d. The lips of the drill form the index to fix the cutting edges in the chuck. This method of placing and of holding the drill insures each lip being ground with the same length of cutting edge.

4th. Adjustable to any angle of drill-point, from 90 to 130 degrees included angle.

5th. Grinds with a flat stone, automatically flooded with water without splash or slop. This abundant and regular supply of water does away with all risk of drawing the temper of the drill while it is being ground.

6th. Nothing is left to the judgment of the workman, who need not be a skilled mechanic.

7th. Wear of parts causes no lost motion.

8th. The emery grinding-stone is fixed on a metal ring, which is bolted to the flange of the spindle, without any danger of springing the spindle or of breaking the wheel while clamping it to place. The grinding-wheels can be removed and replaced with very little delay.

9th. All parts of these machines are made interchangeable, so that any part of any machine can be duplicated with certainty of fit.

10th. A device for pointing the drill is attached to each machine, which device is as general in its use as the grinding machine. All kinds of drills, from smallest to the largest are held in the same way, and are guided by their lips. The sweep or curve of the hollow that thins down the point of the drill is determined by the size of the drill. Placing the drill to be pointed in its chuck sets the stone that grinds the point to the degree of obliquity that will give the proper width to the groove.

11th. Each machine is complete in itself, the fast-and-loose pulleys on the machine are 5 inches in diameter and 3 inches face, and must be made to run about 560 revolutions per minute. A close approximate to this speed is imperative; a lower speed will not do good grinding, a higher speed may break the stone.

THIS machine, the result of long and patient research, is now offered, with the confidence of assured success. While accomplishing remarkable results, it is nevertheless simple in the ex-

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Skilled workmen not needed.

treme. It does not require a skilled workman to operate it. Any careful man, who is not too clumsy in his touch, can, with but a few words of instruction, operate it in an unexceptionable manner.

Drills will last longer.

Drills sharpened on it will last longer and do very much more work before requiring to be reground than if dressed with the utmost skill by hand, and by being pointed with the pointing device will require less power of feed, and cut faster. This is due to the form of the cutting edge produced, which is peculiar to this machine. The clearance obtained is that which has been found to be the best for each part of the cutting edge of the lip, whether close to the centre or at the extreme outside edge; and is totally regardless of the size of the drill, between one-quarter inch and two inches in diameter; as also of the angle of the point, which may be varied anywhere between 90 and 130 degrees included angle.

Clearance of drill.

Angle of point of drill.

Too much stress cannot be laid on the fact that this machine grinds and points any sort of double-lip drill, Fly, Flat, or Twist, equally well; and any size of any kind of drill, within the limits of the capacity of the machine, say from one-quarter inch to two inches in diameter, inclusive, without the aid of any separate chucking devices. All drills of all kinds and every size are held and treated alike, while the precautions to be observed are fewer than in almost any other machine tool.

Grinds all kinds of drills.

The grinding of the lips is done on the face, not on the curved edge of the stone, or grinding-wheel, which wheel is in the form of a ring of emery firmly attached to a true cast-iron back-ring. This back-ring carrying the grinding-stone can thus be attached to the face-plate of the spindle without any danger of breaking the stone, and the attachment is quickly made.

Grinds on side of stone.

Form of stone used.

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In use the grinding-wheel is kept constantly flooded with water, carried to it by a belt-pump (not affected by grit), and is so applied as to produce no slop or splash. Stone kept wet.

The grinding-wheel is kept true on its face by the simple precaution of passing its entire width of face back and forth over the lip of the drill; this insures the face remaining true and flat, and free from grooves or conical places. The legitimate wear of the stone has no effect on the perfection of the grinding. In fact, all parts of the machine liable to wear are not dependent on fit for perfection, so that wear does not injure them or induce lost motion. How to keep stone true on face. Wear of stone does not affect the grinding.

DESCRIPTION OF THE MACHINE.

Fig. 8 shows the machine so far as the grinding of the lip is concerned, with a drill in place ready to be ground. Fig. 9 shows the same machine with the drill-pointing device attached with drill in place ready to be pointed. The machine as thus shown needs only the application of the driving-belts, a supply of water in the water-box below the stone, and all parts well oiled, to be put into immediate use.

The pulley-shaft attached to the machine has fast-and-loose pulleys 5 inches diameter and 3 inches face, and the speed of these pulleys should be 560 revolutions per minute. A lower speed will not do good grinding, a much higher speed might be dangerous. Speed.

The face of the grinding-wheel, Fig. 8, where it shows through the cover-plate, must run downward, and the belts must be so applied as to insure this direction of rotation. Direction of rotation.

The drill to be ground is carried in a holder, which Drill-holder.

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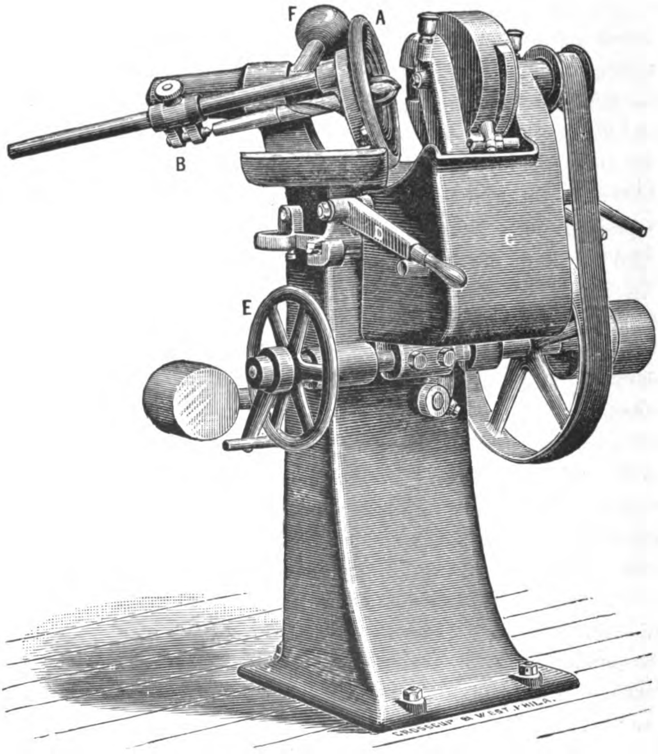
FIG. 8.



PATENT DRILL-GRINDING MACHINE.

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is pivoted to the top of the main upright. The adjustment of the drill to any required angle of point between 90 and 130 degrees of included angle is effected by swinging this holder about its centre. We set the machine and mark the holder for a drill-point of 104 degrees included angle, this having been found to be the best point for all ordinary drilling. The lips of the drill are chucked by two jaws, which are opened and closed by the hand-wheel A. The back end of the drill is steadied by an adjustable centre-stop, B. This stop is made reversible, being provided with a male centre at one end and a female centre at the other, the latter to be used with the small drills having no centre-holes in their ends. The grinding-wheel is carried on a shaft at the top of the water-box C. The lever D, raised and lowered by the right hand of the workman, passes the face of the grinding-wheel back and forth over the lip of the drill. The hand-wheel E adjusts the face of the stone to the lip of the drill; that is, it regulates the cut by setting up the stone closer to or farther from the part to be ground. To this hand-wheel is adapted an adjustable stop, which can be used or not at the option of the operator, its function being to enable an adjustment to be made separately when grinding each lip and yet to permit them both to be gauged to the same length by means of this final stop. If the final grinding of both lips is made without any adjustment of the stone the same result is obtained without the use of this stop.

Adjust to angle of point. **Best angle for point.** **Chucking the drill.** **Back-centre-stop.** **Grinding-wheel.** **Feeding wheel up to the work.**

The grinding-wheel is protected by a cover, except where the drill comes in contact with it. In this cover is a curved water-way, through which water is delivered by an endless-belt pump, and from which it is thrown on the face of the stone and on the end of the drill

Cover over the stone. **Pump.**

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in a continuous stream in abundance, and yet without splash or waste. The return water falls into the tray of the drill-holder, and from thence flows back into the water-box.

Rotation of drill while grinding.

The ball-handle F, operated by the left hand of the workman, rotates the drill back and forth in front of the grinding-wheel in a way to insure the proper clearance, the theory of which has already been explained on pages 16 to 19. All drills of all kinds are held in the jaws in the same way, the jaws being opened or closed after the manner of a scroll or universal chuck. Both of the clamping jaws are provided with *side stops*, one on each jaw, and on one jaw only there is an *end stop*.

Stops on chucking jaws.

TO OPERATE THE MACHINE.

Chucking the drill.

Open the jaws of the chuck by means of the hand-wheel A, insert the drill from the back of the chuck towards the face of the stone, letting the end of the drill rest on the lower jaw, with the cutting edge just touching the end stop; close the jaws temporarily, while the back-centre B is run up and clamped; then release the jaws, hold the drill back against the back-centre B with the left hand, at the same time rotating hard against the two side stops on the jaws; then tightly closing the jaws, clamp the drill by means of the hand-wheel A, using the right hand for this purpose. Throw ball-handle F part way back, and by means of hand-wheel E feed up the stone until it just touches the drill. Bring ball-handle F forward and give additional feed; pass the stone over the face of the drill, back and forth, by lever D, moving ball-handle F back a little between each two cuts. This slices off the stock to be removed; then when entirely over the face of the lip being ground, hold lever D

Grinding.

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stationary, and rotate the drill against the stone by means of ball-handle F. By this means a heavy slicing cut can be taken and a final smooth finish obtained without any risk of drawing the temper of the drill.

Finishing cut.

When one lip has been thus formed, slack up the jaws of the chuck, turn the drill half around, pressing its lips as before against the side stops on jaws, and at the same time be sure to hold the drill firmly back against the back-centre B (pay no attention to the end stop, which is only used in locating the drill endways in the first setting), tighten chuck, and grind the second lip without any readjustment of the stone. The lips will then be of equal length. During all these manipulations the stop that is arranged in connection with hand-wheel E can be slack, and may rest against the pin in the bed made to receive it. N.B.—The use to be made of this adjustable stop is when there has been an adjustment of the stone between the grinding of the two lips and it is desirable to note the final adjustment in each case; that is, one lip can be ground to the stop and then the stone moved back to grind the second lip, ending with the stop against its rest as at the termination of the first grinding.

Reversing drill to grind the second lip.

Use of stop at hand-wheel E.

DRILL-POINTING DEVICE.

Fig. 9 shows the back of the drill-grinding machine with the drill-pointing device in place; it also shows a drill in position ready for pointing. The narrow round-edged grinding-wheel used in pointing, is driven by a cord from the spindle of the grinding machine, and the direction of the cord is shown in the cut. The top of wheel must revolve away from the operator. Ball-handle A controls the chucks that set the point

Grinding-wheel.

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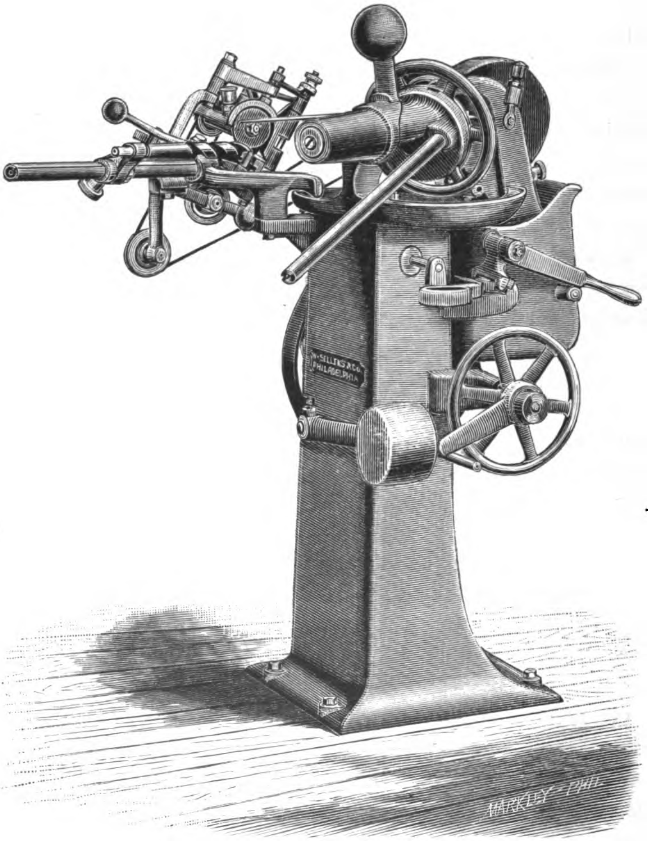
Fig. 9.



PATENT DRILL-GRINDING MACHINE,
SHOWING POINTING DEVICE.

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of drill. It will be observed that the opening or closing of these chuck-jaws causes the grinding-wheel to assume different angles as regards the axis of the drill. The wider they are opened the more obliquely will the wheel be presented to the drill, and the wider will be the groove cut in the drill; for the smallest size of drill, the jaws will set the wheel so that the cut will be as narrow as the thickness of the wheel used. The jaws are carried in slides which are adjustable to any required angle, and these jaws *must* be set to whatever degree the drill-grinding machine is set. The jaws are provided with two sides and one end-stop to guide or place the drill, and a back-centre B, to steady the shank of the drill.

Chucking jaws.

TO OPERATE THE MACHINE.

Position of workman.

The workman stands with the bar C to his right hand side. Holding the drill in his right hand, he opens the clamping jaws by means of the ball-handle A, using his left hand for this purpose. Rotating the drill in the direction it would run in drilling, he brings the left hand lip up *under* a stop on the left hand jaw, and the right hand lip is brought *down* on to a stop on the right hand jaw, while at the same time, the drill is made to touch lightly an end-stop on the right hand jaw. Allowing the jaws to close in this position of the drill, the back-centre B is run up with the left hand and made fast. The wheel is now passed over the point by means of the left hand resting on the frame at D, and the adjustment of the height of stone, or depth of cut being made by the milled nut E. This nut is furnished with graduations to enable the wheel to be set at the same height in cutting the two sides of the drill. Having ground

Setting the drill.

Grinding the point.

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one side of the point, the jaws are opened and the drill turned upside down, observing that it is back against the back-stop, and up against the side-stops for the lips.

PRECAUTIONS TO BE OBSERVED.

The precautions to be observed, and which should be impressed on the workman, are:

1st. He must not allow the grinding-wheel to touch the end of the chuck-jaw.

2d. He must follow the directions given in setting the drill, else he may pry off the end stop.

3d. He must use the stone as directed, to keep it straight on its face.

4th. All running parts of the machine must be kept well oiled and good wicks in the oil-cups. The scroll-chuck holding the jaws must be kept well oiled, and taken apart and cleaned occasionally.

5th. The water-box should be cleaned out from time to time. To do this, slack up the nut on the fulcrum of lever D, and draw out the lever from its stop until the box will turn over on its joint like a hinge and its contents thus emptied into a bucket.

6th. The cover plate in front of the grinding-wheel should be adjusted in reference to distance from face of wheel to produce the best current and avoid splashing. It must be kept moderately near to the face of wheel.

7th. The end stop on one of the clamping-jaws that hold the drill in the chuck determines the setting of the drill in proper position endways. If this stop is broken off, and the machine is used without it, there is nothing to determine the position of the drill endways; and if, under these circumstances, the drill

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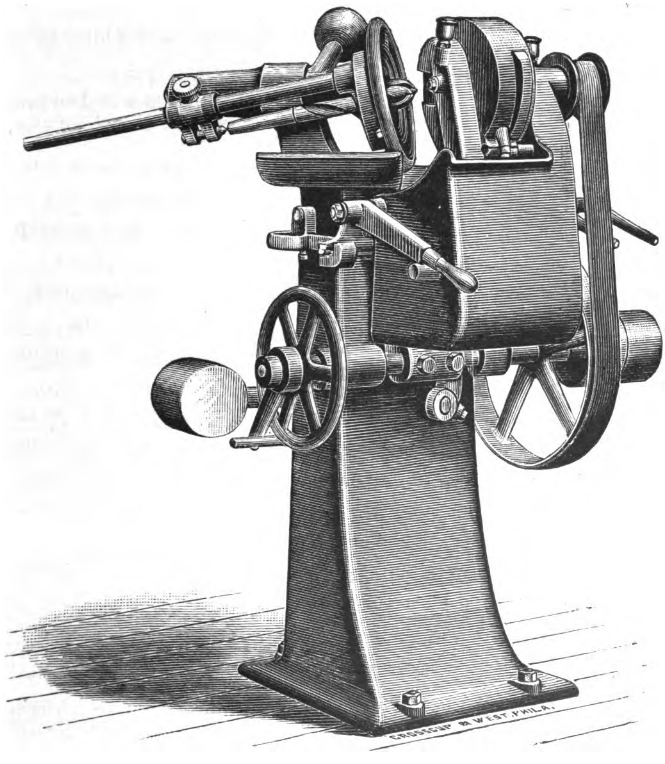
is made to project further through the jaws than the stop would have permitted, the grinding will not be satisfactory.



PATENT DRILL-GRINDING MACHINE.

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SURFACE GRINDING MACHINE.

(*For Report of Judges, see page* xii.)

Arranged to grind flat surfaces of hardened steel. The top plate, or table, of cast iron, with hard steel plate at centre, made truly plane. Emery wheel on hardened steel mandrel, running in composition bearings. Frame that carries the frame-table arranged to set on ordinary work bench. Counter-shaft to be placed on floor below it, has fast and loose pulley 5 inches diameter, $2\frac{1}{2}$ inches face, which should make 320 revolutions.

Scraped surfaces.

THE introduction of true surface plates for use in machine shops has rendered the production of plane surfaces in cast iron, or other metals that can be worked by scraping, a comparatively easy matter. But a want has been long felt for some means of producing a true plane on hard substances, as, for instance, on hardened steel. Our surface grinding machine is, in fact, an abrading or grinding device in the centre of a true plane; the abrading mechanism being adjustable to any degree of depth of cut. Hard surfaces passed back and forth over this abrading mechanism, come in time to be a copy of the plane surface upon which they rest. The cutting is done by an emery wheel on a horizontal axis, the edge of the wheel extending just through the plate. The surface plate, which is 18 inches long by 8 inches wide, rests on two supports at one end, and on an adjusting screw at the other. This little machine, like the drill grinding machine, page 40, finds its proper place in the tool-room, and serves an admirable purpose in the production of hardened straight edges, and in dressing up flat surfaces of dies and cutters.

Emery wheel.

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DRILL PRESSES.

UNDER this head we class all machines used for boring, in which the cutters revolve and the work remains stationary; while under the head of BORING MACHINES we place those machines used for boring only, or boring and turning, in which the cutters are stationary and the work operated on revolves.

Some of the machines classed under the head of drill presses are known as boring machines, the word "bore" being commonly applied to holes of a size requiring the use of independent cutters inserted in a "boring bar." We are satisfied that a power feed is essential to all machines for cutting metal. The drill press is no exception to this; yet it is almost the only machine tool which has commonly been built with a hand feed only. The conditions of cut and variations in the size and strength of the cutting tool make the application of an automatic feed to a drill press a more difficult matter than to a lathe or a planing machine, in which a given-sized cutting tool of sufficient strength to do the work is possible. In a drill press the smaller and more delicate the drill the finer and more exact or uniform must be the feed. The requirements of a good feed motion for a drill press are: that it may be quickly adjusted to the required amount; that it shall be positive in its action when at work; that its range shall be so great, and so fine a feed possible, as not to endanger the smallest drill, while at the same time it shall be capable of giving the utmost amount of feed a large drill or a boring bar will stand; that it shall be so quickly and readily applied as to make its use more convenient than the hand feed; and that it shall not in any way interfere with the quick operation of the machine by hand.

The introduction of our improved adjustable feed motion fully satisfies all the requirements of a feed for drilling machines. In

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this we employ discs of metal to transmit motion by friction, which, being adjustable as to diameter of driving and driven wheels, admits of an infinite variation of feeds between its extreme limits of greatest and least motion. This peculiar feed motion is applied to those of our drill presses in which range is desirable; but in machines for special work, such as our press for drilling steel rails, the feed is constant, at what has been found to work the best, as the size of the drill used in such machines is in a measure constant also. In vertical drill presses we always counterbalance the spindle. This is of great value, as the drill held up by the balance-weight will not drop into holes or cavities in the metal, and is much less liable to break.

We would also call attention to a recent improvement in horizontal drills, whereby we can readily and quickly shift from a fine feed for the roughing cut to an exceedingly coarse feed for the finishing cut. This enables the finishing or sizing cutters to be hurried through their work, with a great saving in time, with less wear of the cutters, and consequently with more accurate results, especially in deep holes.

There are also many improvements in this class of machines, which will be alluded to under the heads of the respective tools. In this introduction we merely wish to call attention to the features common to almost all our drill presses.

We have recently added to our list of drill presses two sizes of radial drills, to which we call attention. These machines are made with many conveniences in the mode of handling, rendering them very efficient.

In regard to the proper shape of the cutting edges of the drills themselves, we present under the head of Drill Grinder, pp. 25 to 39, our views on this subject, and explain how they may be cheaply maintained in good order at small expense.

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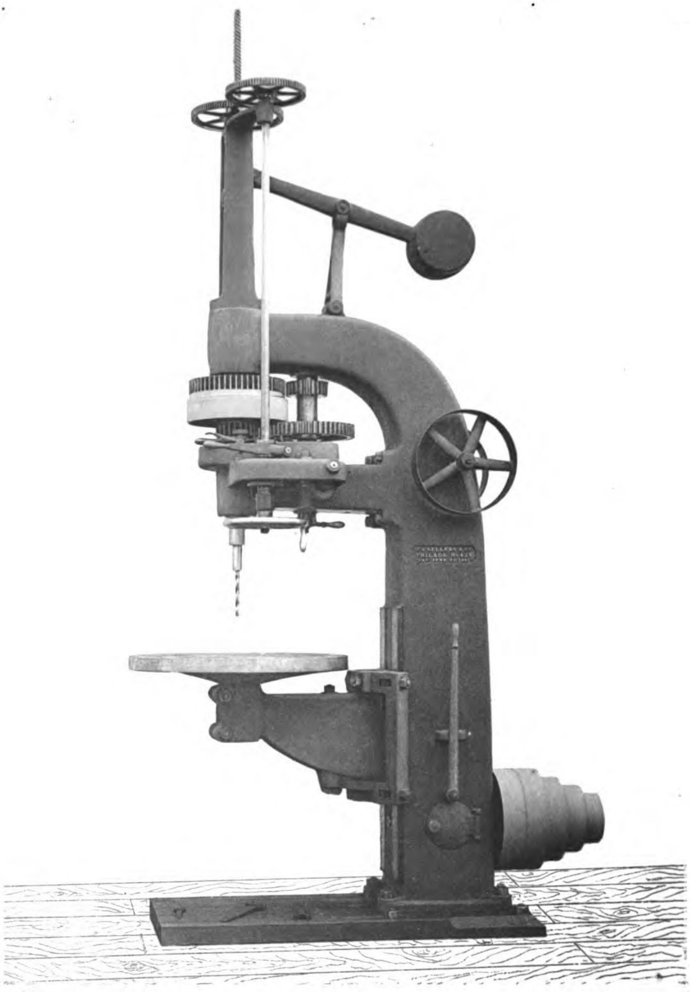
FIG. 12.



Phototype, F. Gutekunst, Philada.

45-INCH DOUBLE GEARED VERTICAL DRILL.

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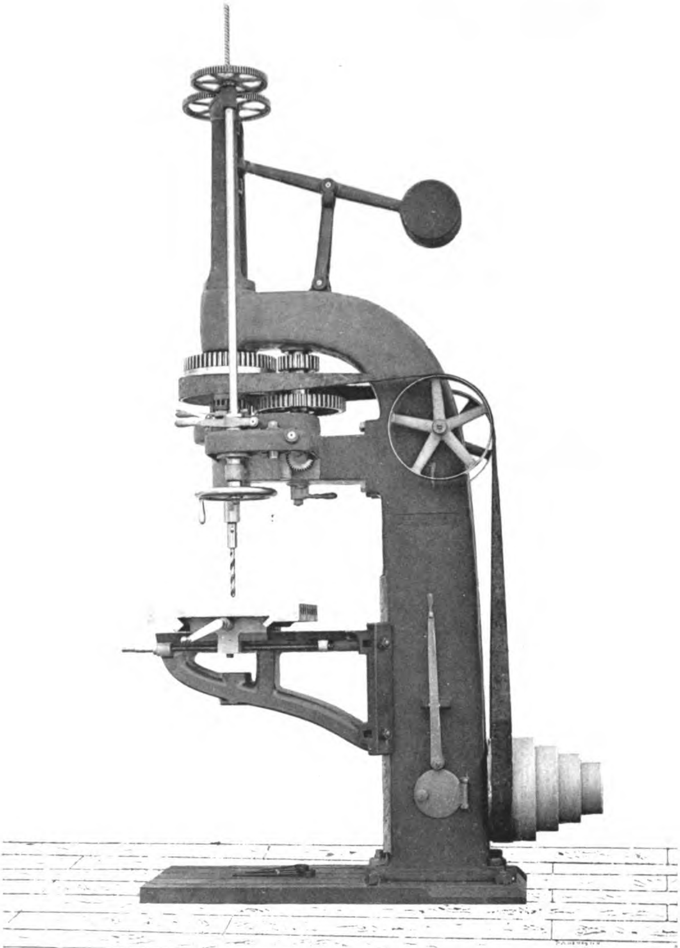
FIG. 13.



Phototype. F. Gutekunst. Philadelphia.

45 Inch DOUBLE GEARED VERTICAL DRILL.

WM. SELLERS & CO. PHILADELPHIA, U. S. A.

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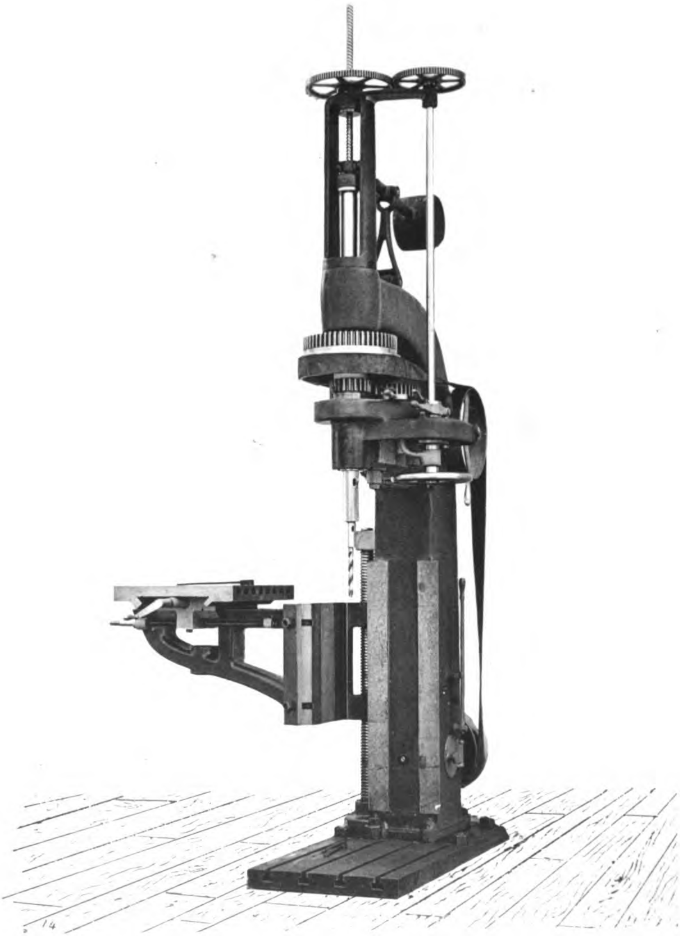
Fig 14.



45-INCH DOUBLE GEARED VERTICAL DRILL.

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PATENT DOUBLE-GEARED VERTICAL DRILL.

(*For Report of Judges, see page* xviii.)

With column of improved rectangular form, secured to a slotted floor-plate. Plain or compound tables, or circular rotating table on swinging bracket, raised or lowered by power. The table arranged to swing to one side to enable work to be bolted to the floor-plate. The knee carrying the compound table is provided with a bearing to steady the lower end of a boring bar. Drill spindle of best cast steel, counter-balanced up and provided with quick hand motion and improved variable power feed. Driving pulley on the spindle, so that when back gear is not in use the spindle is driven by belt only, producing a particularly smooth motion, very desirable when small drills are being used. Cone pulley is at base of the machine, admitting ready change of speed; counter-shaft is furnished with 10″ fast and loose pulleys, 4″ face, which should make 110 revolutions per minute. A full set of wrought iron wrenches is furnished with each machine, and all wrought iron work is case-hardened.

The 45″ vertical drill has an over-reach of 22½″ from centre of spindle to face of column.

THIS machine, for holes of 1½″ and under in cast iron, has its spindle driven by belt only, but is provided with back gear to be used for heavier work. This belting system has been found to work much better than the geared plan of driving in common use; and in practice we find that, in comparison with machines of otherwise similar capacity and power of cut, the same workman can do 15 per cent. more work on this machine than on the old styles. In an experiment with small drills, the power feed was used in boring a ¼-inch hole through 3 inches thickness of wrought iron successfully, and in less time than a similar hole was made by a skilful workman feeding by hand. **Driving by belts.**

The supporting post of this machine is rectangular, and the bracket carrying the compound table is gibbed to a plain surface. The raising and lowering **Post.**

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Table.

of the table are effected by a screw placed at one side of post in such a position as to enable the table to swing about it as on a hinge, after slacking the shoe on the opposite side of the bracket. This enables the table (see Fig. 14) to be readily removed for the introduction of such work as can more conveniently rest on the floor plate, which is 22½″ wide, and has slots for holding-down bolts. The raising screw is driven by power, operated by a hand lever at the side of the upright, so as to give the utmost facility of adjustment. We make this tool with plain table, when required; but in the majority of instances in which purchasers have selected the plain tables they have afterwards ordered the compound tables to replace them, the latter presenting so many advantages. In order that the tool may be used for boring purposes with double-ended cutter up to the capacity of the power, with the back gearing in use, we arrange in the bracket a hole to carry a guide bushing to support the lower end of the boring bar and to give it steadiness under cut.

Raise table by power.

Guide for bar in bracket.

To supply the want of a plain table that will permit work already bolted to place being moved about under the drill spindle, we make also a very convenient circular table (see p. 44), 32 inches in diameter, mounted on a swinging arm or bracket, which is hinged to the slide which travels on the upright, so that this form of table can be readily swung entirely away to admit the work that is better bolted to the base plates, as in the case of the compound and plain tables. A central hole 2¼ inches in diameter is bored true to the spindle to guide the boring bar when the table is in its central position, and clamps are provided to secure the circular table against rotation when it is set to place, and

Circular swinging table.

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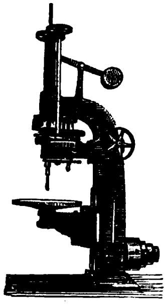
also to secure the swinging bracket to any required position. This form of table, like the compound table, has the advantage of permitting all parts of the table being brought in turn under the drill, but the motion is not in right lines. Holes are provided in the circular table to admit holding-down bolts. **Advantages.**

On counter-shaft there are 10 inches by 4 inches fast and loose pulleys, making 110 revolutions per minute. Cone pulley has four changes of speed. **Speed.** We have recently made very important improvements in this machine, to which we call attention. The stroke of the spindle has been increased; it now has a motion of 17½ inches. We have introduced a new system of feeds, positive in action and of very wide range. These feeds are proportioned to the kind of drilling to be done. When the back gear is not in use and small drills are to be driven, the range of feeds is through a finer series than when the back gear is being used, and large drills or boring bars are to be driven.



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36-INCH VERTICAL DRILL.

Spindle of best cast steel, having a motion of 12″, driven by belt only when back gear is not used, and counter-balanced up, feed automatic and variable through a great range, adjusted with ease, and operated instantaneously. Post or upright rectangular in form, with a plain table gibbed to the front of it, and raised and lowered by power. Plain table 26″ long by 18″ wide, with holes for holding-down bolts. Also made with rotating circular table on a swinging bracket when required.

Furnished single geared only, or with back gear. The counter-shaft for single-geared drill has fast and loose pulleys 12″ diameter, 4″ face, the counter-shaft for back-geared drill has fast and loose pulleys 10″ diameter, 4″ face, the speed in both cases being 110 revolutions per minute. The cones on both drills have three lifts.

Full set of wrought iron wrenches furnished, and all wrought iron work case-hardened.

THIS machine is made either single or double geared, as may be required. The single geared drill has a capacity of say one and a half inch hole in cast iron, thus meeting the wants of a great part of the general shop practice. The double-geared drill can be used with larger drills or with boring bars. The feed motion is of our most improved kind, adjustable through a wide range, and being instantaneous in its action. We make these machines with a plain table, to fill the want for a cheaper tool than the patent double-geared drill press described on page 49, and we also furnish when required a rotating circular table, 26″ diameter, mounted on a swinging bracket similar to that described in connection with our patent double-geared drill on page 50. The peculiarly smooth motion imparted by the belt to these tools enables them to do more work, especially with small drills, than is possible with drills driven by bevel wheels on the spindle. The absence of all noise and rattle, too, is itself a recommendation.

Feed motion.

No noise.

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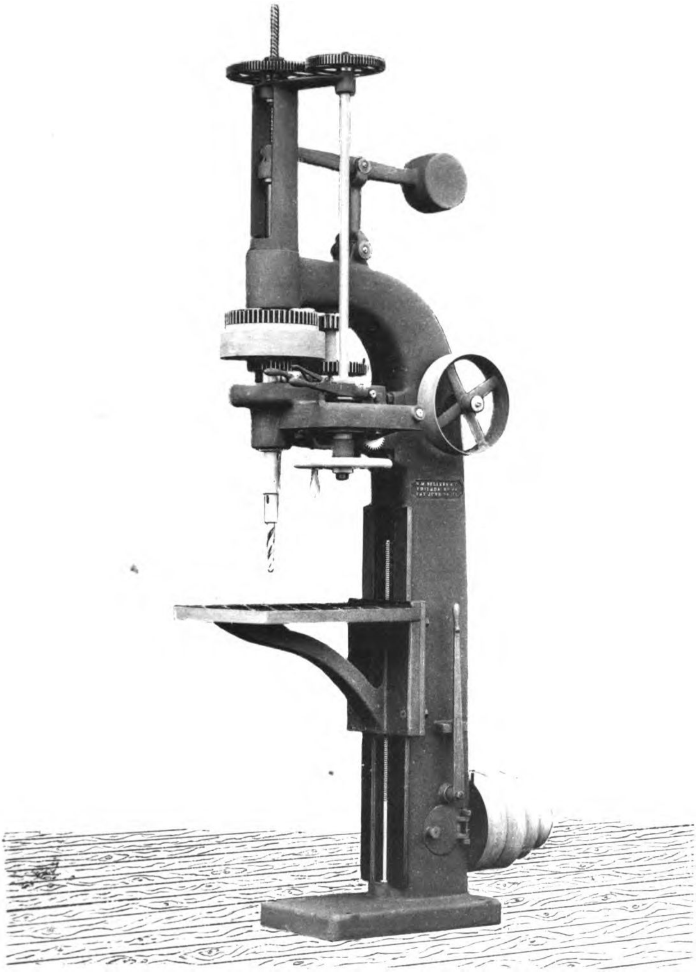
FIG. 15.



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36-INCH DOUBLE GEARED VERTICAL DRILL.

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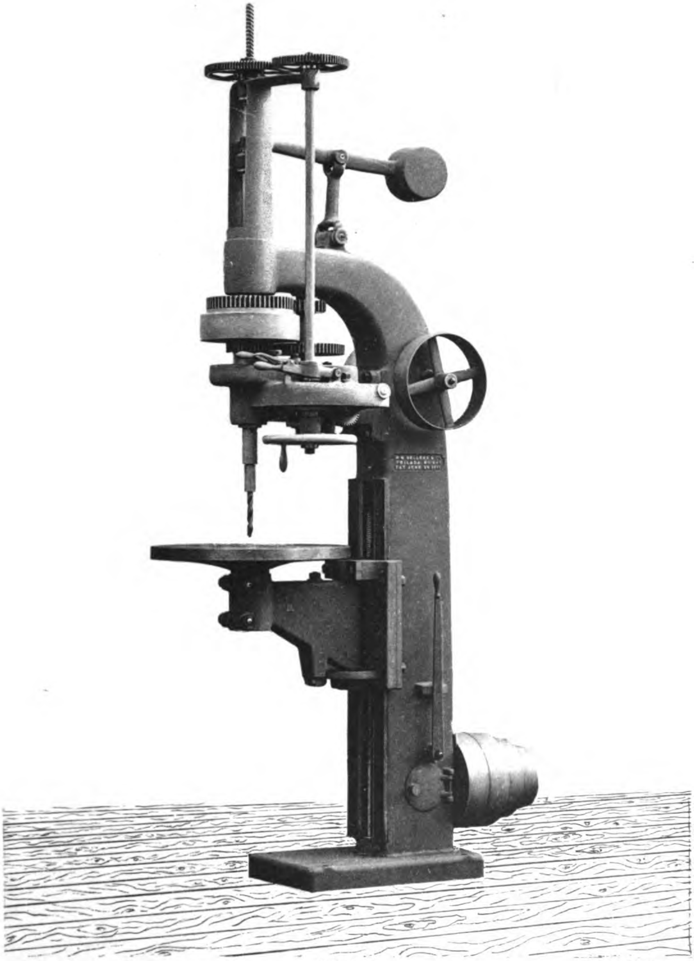
FIG. 15A.



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36-INCH DOUBLE GEARED VERTICAL DRILL.

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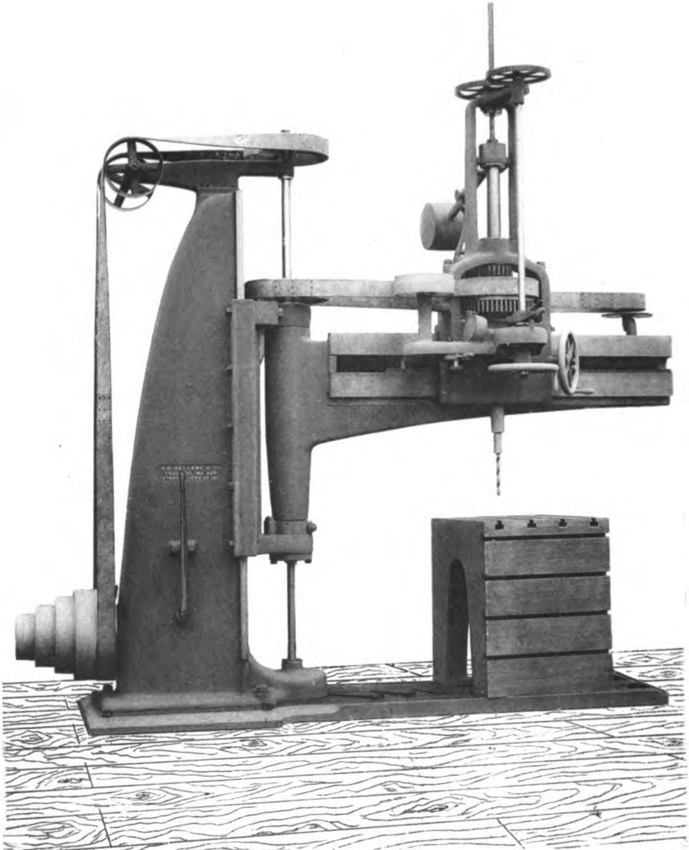
FIG. 16.



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72-INCH RADIAL DRILLING MACHINE.

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RADIAL DRILLING MACHINE.

With substantial, well-braced upright secured to a slotted bed or floor plate. The swinging arm is hinged, crane fashion, to a long saddle fitted to slide freely on the face of the upright, but of such length and closeness of fit as to avoid all need of clamping the saddle to place. Saddle raised and lowered by power. Drill spindle carried close to the face of the swinging arm, and moved back and forth by means of a spiral pinion and rack, after the manner of the driving gear of our planing machines. The cone pulley is placed at the foot of the upright, in a convenient position for changing the speeds; from this pulley belts are carried to the drill spindle over guide pulleys, and without the intervention of any gear wheels, thus utilizing the system of belt driving, proved to be of so much value on all our various styles of vertical and horizontal drills. Improved adjustable automatic feeds, arranged in two series, the finer series used when the drill is driven by belt only, the coarser series for large drills driven by the back gear. The drill spindle is of the best cast steel, and is counter-balanced up. Square table 30″ high, with slots for holding bolts on top, and on one side for the ready holding of small work. Full set of wrought iron wrenches furnished, and all wrought iron work case-hardened.

The 54″ radial drill has an over-reach of 43″, with 12″ stroke of spindle. Greatest height of nose of spindle from floor plate, 62″. Counter-shaft arranged with fast and loose pulleys 10″ diameter and 4″ face. They should make 110 revolutions per minute.

The 72″ radial drill has an over-reach of 59″, with 17¼″ stroke of spindle. Greatest height of nose of spindle from the floor plate, 67″. Counter-shaft arranged with 10″ fast and loose pulleys, 4″ face. They should make 110 revolutions per minute.

OF these two machines, the 72″ size (see Fig. 16) corresponds in power with our 45″ vertical drill; the 54″ size (see Fig. 17) corresponds with our 36″ vertical drill. The value of a radial drill consists, primarily, in the readiness with which the drill can be moved to the work, or shifted over the various parts of the work requiring to be drilled. In the use of radial drills having the swinging arm at one fixed and unalterable height above the floor plate, the work must either be blocked up to suit the height of the machine, or extension pieces must

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be used to lower the drill to the work. In our machines the swinging arm is raised and lowered by power, and thus quickly adjusted to the proper height, so that the work to be drilled has only to be brought under the drilling machine in any convenient position and height, and the drill is then quickly set to suit the height of the work, thus saving much time. Too much stress cannot be laid on this feature of these drills. As the saddle carrying the swinging arm is so fitted and of such a length as not to require any bolting to place, this adjustment of height is rendered simple in the extreme.

Radial arm raised and lowered by power.

The feed motion is obtained through our improved adjustable feed discs. It has a wide range through two series, one for the single gear, the other for the double gear, and can be put on or off instantaneously by a tap of the hand on a lever close to the hand-wheel. All the adjustments of the machine are quickly made, the shifting of the back gear into or out of use being as readily done as on any well-made turning lathe.

Feed discs.

We arrange a convenient clamp at the bottom joint of the swinging arm to enable the radial arm to be secured in position; but if the drills used are correctly formed and run true, the arm needs no clamping to place.

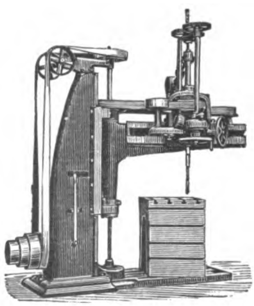

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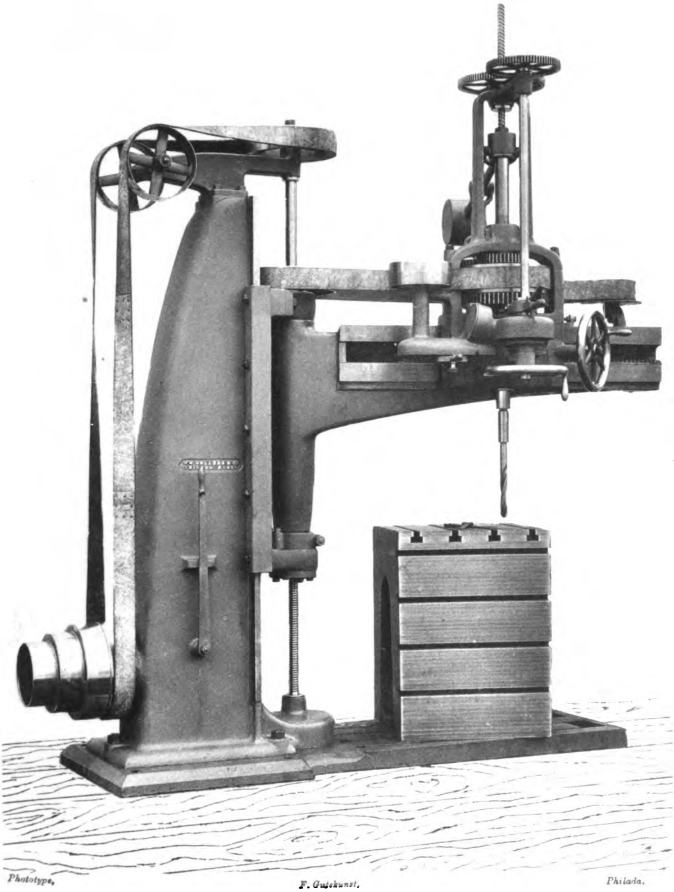
Fig. 17.



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54-INCH RADIAL DRILLING MACHINE.

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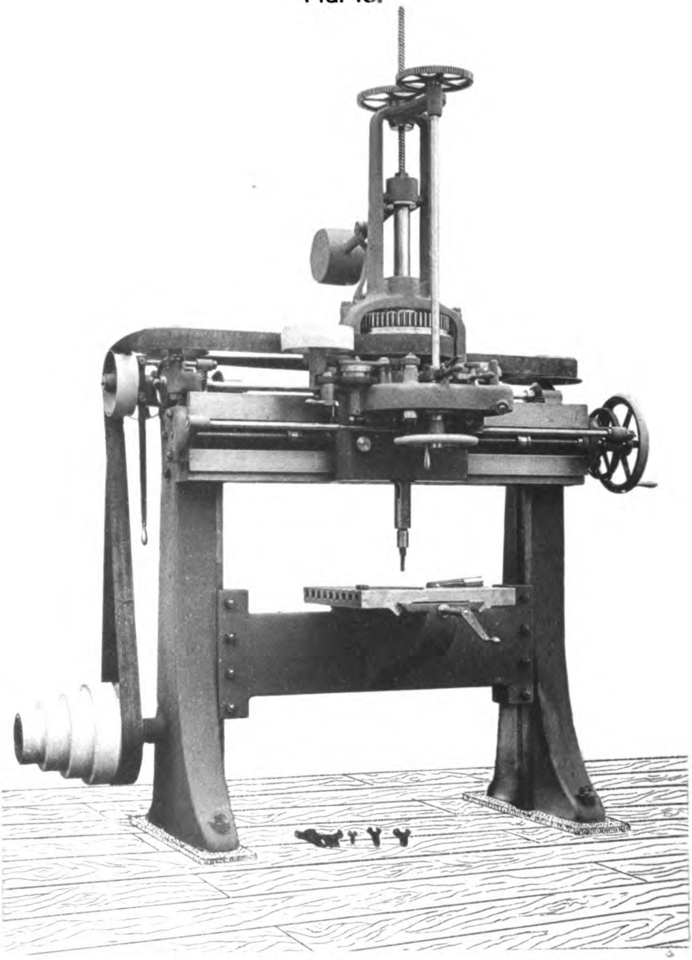
Fig. 18.



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TRAVERSE DRILL PRESS, WITH COTTER DRILL ATTACHMENT.

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IMPROVED TRAVERSE DRILL WITH COTTER DRILL ATTACHMENT.

Arranged with cross-head, carried by two uprights. Space between uprights, 50¼ inches; height of cross-heads from the floor, 52 inches; over-reach of drill spindle beyond face of posts, 10 inches; transverse travel of drill spindle, 3 feet. Will cotter or drill holes 10 inches from the edge of a plate, or key-seat cylinders, 20 inches diameter of any length. Pieces 50 inches wide will pass between the uprights. Table of machine 24″ x 24″ with 24″ motion at right angle to the line of traverse of the saddle. Table raised and lowered by power. Drilling machinery driven by belt direct to the spindle. The machine is either a traverse drill or a cotter drill, at the will of the operator, the change from one to the other being instantaneous, and involving no complication of movements. When the cotter drilling machinery is not in use it is entirely idle and subject to no wear whatever. As a cotter drill the motions are uniform, the side travel and the down feed being both adjustable through a wide range of feeds. As a drill press the power is the same as our 45″ vertical drill. Full set of wrought iron wrenches is furnished, and all wrought iron work is case-hardened. The counter-shaft is provided with fast and loose pulleys 10″ diameter and 4″ face. They should make 110 revolutions per minute.

THE amount of cotter drilling to be done in any one establishment is seldom enough to keep a machine for only that purpose busy. Most cotter drills are of no use for any other purpose. The drill we now offer is designed to do the work of a drill press in a superior manner, and is so arranged as to be instantly converted into a cotter drill. Such a machine, it will be readily seen, need never be idle. This drill press is a traverse drill, with three feet of motion to the saddle carrying the spindle, this motion being at right angles to the motion of the table to which the work is bolted. The table motion is 24″, so that the space covered at one setting is 36″ x 24″. The table is quickly raised or lowered by power. Capacity of machine.

The drilling-head is provided with back gear, but the belt pulley is on the sleeve which contains the

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drill spindle. In this respect the machine is like all our belt-driven presses.

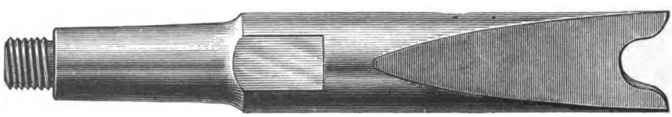
COTTER DRILL ATTACHMENT.

Upon the saddle is carried the mechanism required to work the tool as a cotter drill. These devices do not run when the machine is used as a drill press only; and are therefore not then subject to wear. The attachment of the cottering devices, when required, is simple in the extreme,—moving one gear wheel into position, and turning two eccentrics, is all that is required to be done. The traverse of the saddle sideways in cotter drilling is accomplished by means of a peculiar arrangement of screw and adjustable nuts, which can be instantly set to the required length of slot, and insures a uniform motion, back and forth, at each stroke, the length of the stroke being uniform, as is also the rate of its advance. The down feed occurs at each end of the lateral motion, and the saddle is at rest when the down feed is made. The vertical position of the drill spindle is of great advantage in cotter drilling wrought iron or steel, as the slot in process of cutting can be kept full of oil.

Side motion by means of screw.

Oil in slot while drilling.

Fig. 18[a], facing this page, shows a traverse drill without the cotter drill attachment.



COTTER DRILL.

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FIG. 18A.

PHOTOTYPE F. GUTEKUNST PHILAD'A.

TRAVERSE DRILL.

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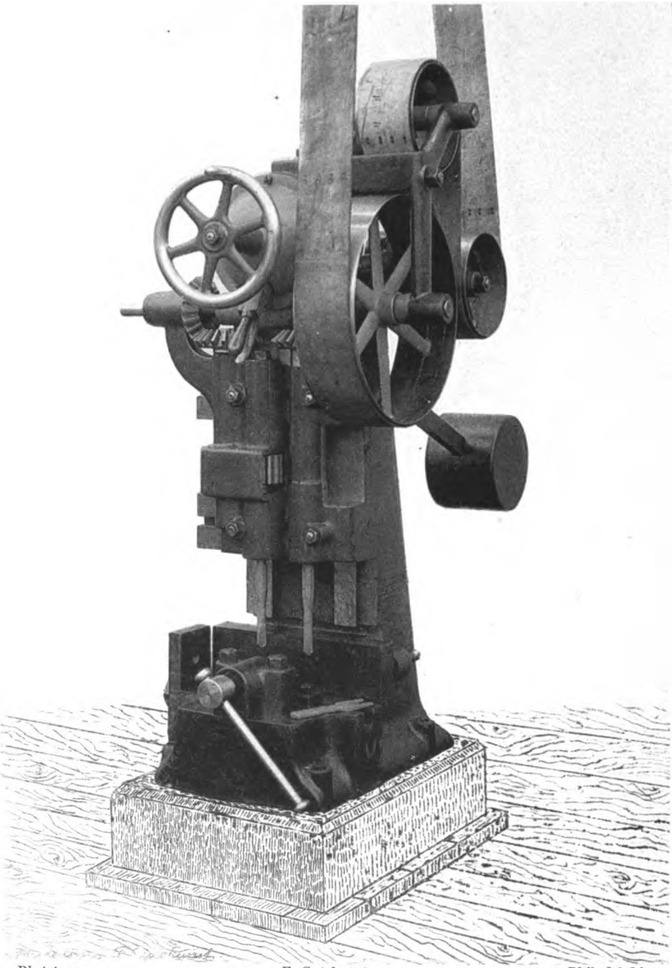
Fig. 19.



Phototype. F. Gutekunst. Philadelphia.

DRILL PRESS FOR STEEL RAILS.

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RAIL DRILLING MACHINE.

With square column and projecting knee to receive the rail: intended to be brought to proper height to suit trussels in mill by resting it on foundation or pier built to a proper height. Drills adjustable in a right line, so as to be placed either 3 inches from centre to centre, or 8 inches apart if required. Powerful down feed of both drills simultaneously, and a quick return by hand movement. Spindles of best cast steel. Counter-shaft with fast and loose pulleys, 20 inches diameter, 4 inches face, which should make 186 revolutions per minute. Wrought iron work case-hardened. Clamp vice for holding rail attached to the bed.

THE introduction of steel rails has necessitated the use of drilling machines to make the holes for the joint bolts near the ends of the rails. In designing this machine for the above purpose, we had in view the most efficient mode of driving the two drills, and the readiest means of adjusting them to the proper distance apart. The feed is a positive, unvariable one, and is the utmost that has been found possible to use. Rapid drilling in steel is attainable rather by high speed of cut with fine feed than by a slower speed with a coarser feed. **Speed of cut.**

These machines are always used in pairs, one machine to each end of the rail; but not necessarily both drilling at the same time on the same rail.

Lubricant used. Animal oil should be used in drilling steel and wrought iron; coal oil will not do. A free use of water containing soda or soap will answer a better purpose than coal oil, and will do almost as well as lard or whale oil.

We have also arranged these machines on a bed plate, upon which they traverse back and forth, enabling them to be used as a multiple drilling machine.

To keep the drills in proper order for work, we recommend our drill-grinding machine, as shown on pages 25 and 39.

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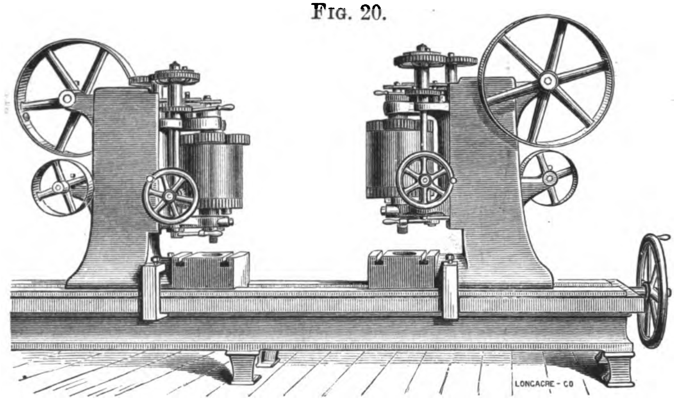
FIG. 20.



DOUBLE TRAVERSE DRILL.

IN preparing links for bridge-work, it is advisable, in order to insure accuracy in length, to bore the holes for the pins in both ends at the same time. For this purpose we make right- and left-hand boring machines, sliding on a solid bed, and adjustable to or from each other, to suit the required length of links. The boring machines are so placed as to permit the links to be put in place from one side, and, when done, passed out on the other side of the machine. The driving is effected by horizontal belts passing over guide-pulleys, and around a drum on the spindles. The cutters used in this machine are kept cool by water fed to them through the centre of the spindle.

Expansion of the bed.

In the link boring machine the two heads are united by bars of wrought iron and can slide freely on the cast-iron bed. The expansion of the wrought-iron bars being the same as the expansion of the link being bored, insures uniformity in the length of the finished work.

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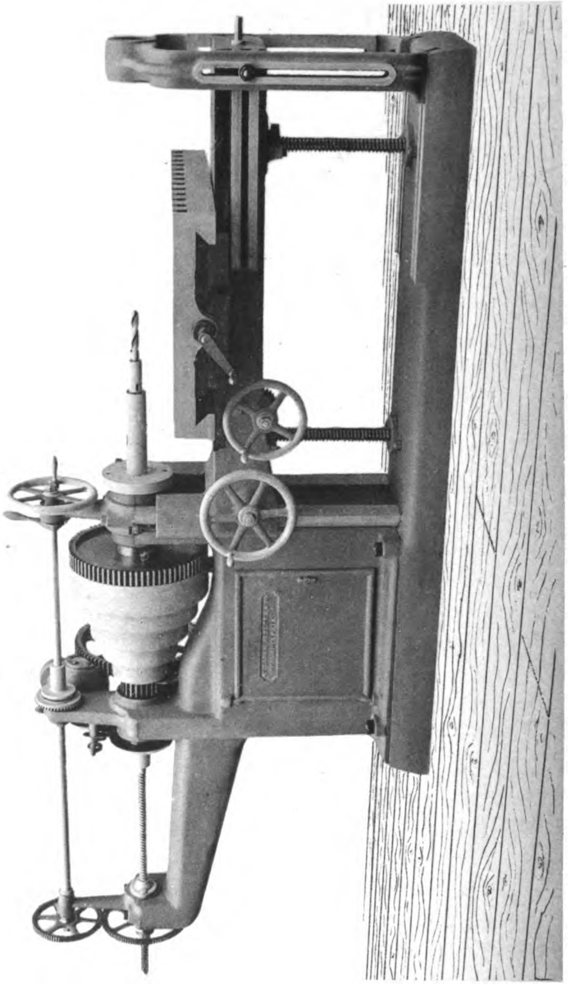
Fig. 21.



HORIZONTAL DRILLING AND BORING MACHINE.

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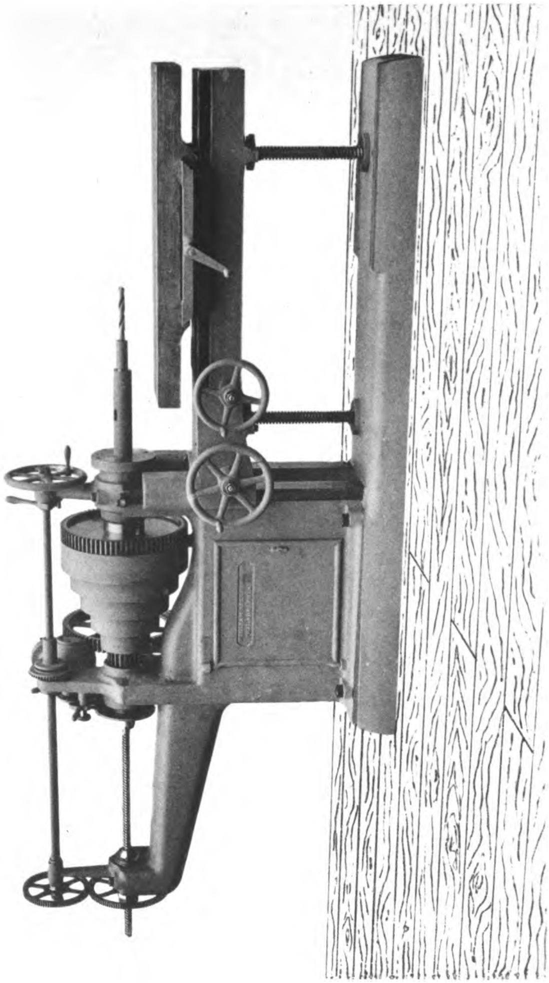
FIG. 22.



HORIZONTAL DRILLING AND BORING MACHINE.

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HORIZONTAL DRILLING AND BORING MACHINE.

With improved variable feed and quick hand traverse in boring spindle, arranged so as to be changeable instantly from one to the other; compound table arranged to raise and lower, with horizontal movement at right angles, and parallel to drilling spindle; arbor which carries the drilling spindle arranged with face plate, so that the machine can be used as a facing lathe; length of traverse to drilling spindle, 30 inches. Diameter of piece which will swing over the table, 51 inches. Counter-shaft with iron cone pulleys turned inside, so as to be perfectly balanced; ball and socket hangers, and fast and loose pulleys, 16 inches diameter and 4 inches face, which should make 75 revolutions per minute. Full set of wrought iron wrenches. All wrought iron work case-hardened.

With or without out-board bearing to carry the end of boring-bar. The machine, with out-board bearing, has the long way of the table across the machine; size of table, 48″ by 28″. The machine, without the fixed bearing, has the long way of its table, parallel with the spindle. Its table is 48″ by 23″, and the bolt slots run lengthways with the table.

Extra slide rest to bolt on face plate, for squaring pipe flanges or facing off work, furnished to order.

THIS machine, designed to bore and drill horizontally work resting on a table or platform, has been considered by some engineers as coming next to the lathe in usefulness in the shop. It will drill work that cannot be operated on in an ordinary vertical drill press, and has all the advantages of a facing lathe for some kinds of work.

Advantages.

Marked advantages which this machine has over similar tools of other makers lie in the nature of the feed motion, which, by use of the friction feed discs, admits of an infinite variety of feeds between its finest and its coarsest; in the ready application of the feed, and its quick hand motion; also in the manner of operating the compound table upon which the work

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rests, the handles to govern the motion of table being all on one side and within easy reach of the workman. The screws which raise the table require holes in the foundation below the bed; as when the table is lowered they project below the base of machine. If placed in damp places, the boxes or recesses in foundation for these screws should be made water-tight.

Foundation.

As shown in the specification of these machines, we provide an out-board bearing when that style of machine is required. This bearing is carried from the bed plate, arching over the knee which carries the table; it bolts to the bed plate, and to the knee also. It can be placed 29″ from the face plate, or it can be moved off to 53″ from the face plate; it does not interfere with the ready adjustment of the table vertically. In our own practice we prefer the machines arranged without this bearing, as it is in the way in drilling long work. We prefer to use an adjustable bearing, which we bolt to the table close to the work, and which we consider more solid. For this purpose we make a very convenient adjustable bearing, or steady rest, readily applied and quickly set to suit the position of the boring bar. The feed motion now applied to these machines is arranged in two series, a fine and a coarse, both of these series being applicable to any speed or any size of drill. The value of the coarse feed will be felt in all kinds of boring with bars and cutters, inasmuch as it is possible to rough out with a fine feed, and to finish with a light cut and a very coarse feed. In this way the finishing cutter is hurried through the work, is less liable to wear in the length of the hole to be bored, and much time is saved.

Out-board bearing.

Adjustable bearing for bar.

Feed motion.

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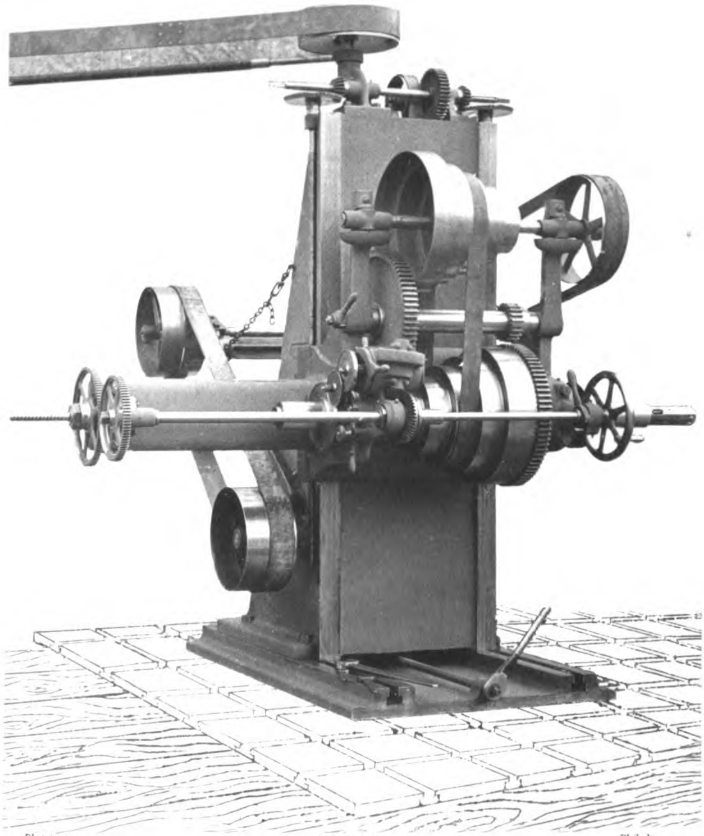
Fig. 23.



FLOOR BORING MACHINE.

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FLOOR BORING MACHINE.

Consisting of a powerful horizontal drill press mounted on a stand, movable to position on a heavy bed-plate, the work being stationary. The bed-plate is provided with T-shaped slots for the convenient clamping of work, and is 20 feet long by 5 feet wide.

THE Horizontal Drill Press having proved itself in our own practice so useful, suggested a machine which could itself be moved about the work, while the work, too heavy to be moved on the table of another machine, could be clamped on the floor, and there held until all the boring was completed.

To this end we have arranged a large floor-plate provided with T-shaped slots on which the machine may be clamped at any horizontal angle to the work; for such work it is much more convenient than the stationary machine, because the work once bolted to the floor need not be moved until the work on it is entirely completed. **Floor plate.**

The boring machine itself is provided with all the devices for feed and speed found in our stationary horizontal drills. **Boring drill.**

The boring bar may be moved vertically from within 14 inches of the floor, to a height of 6 feet 4 inches, thus making it capable of boring any horizontal hole. **Amount of motion.**

When the bar used is a long one, steady rests are provided which may be bolted to the floor, to support the outer end of the bar.

Motion is conveyed to the machine by means of pulleys on a swing frame, thus allowing the machine to be moved to any position on the floor, and at the same time keep all the belts tight. **Swing frame.**

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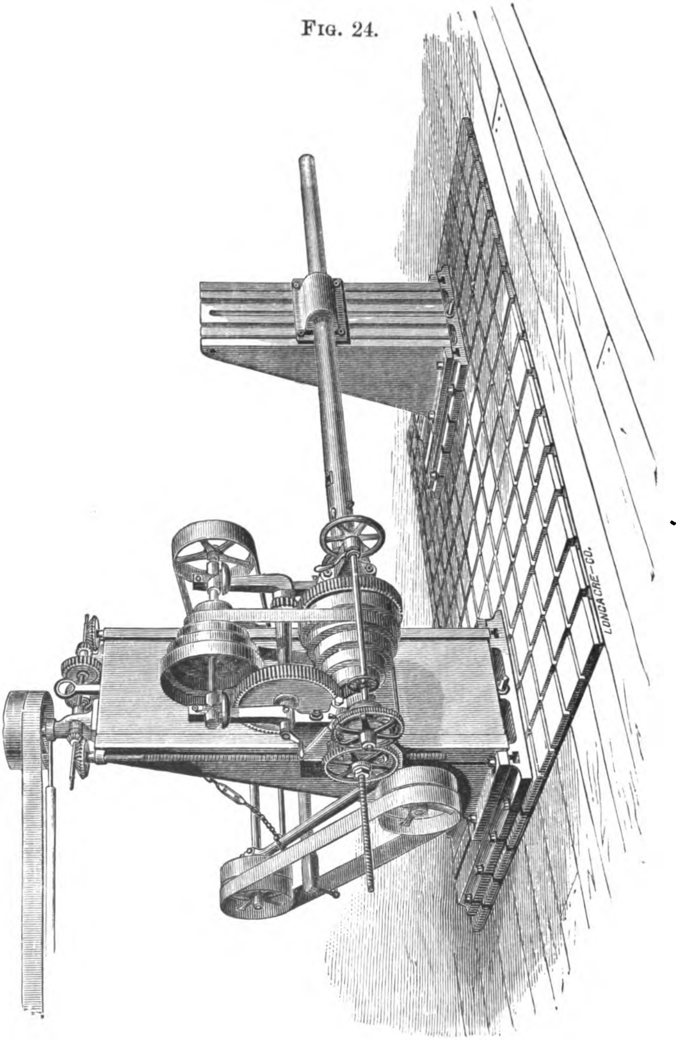
FIG. 24.



FLOOR BORING MACHINE.

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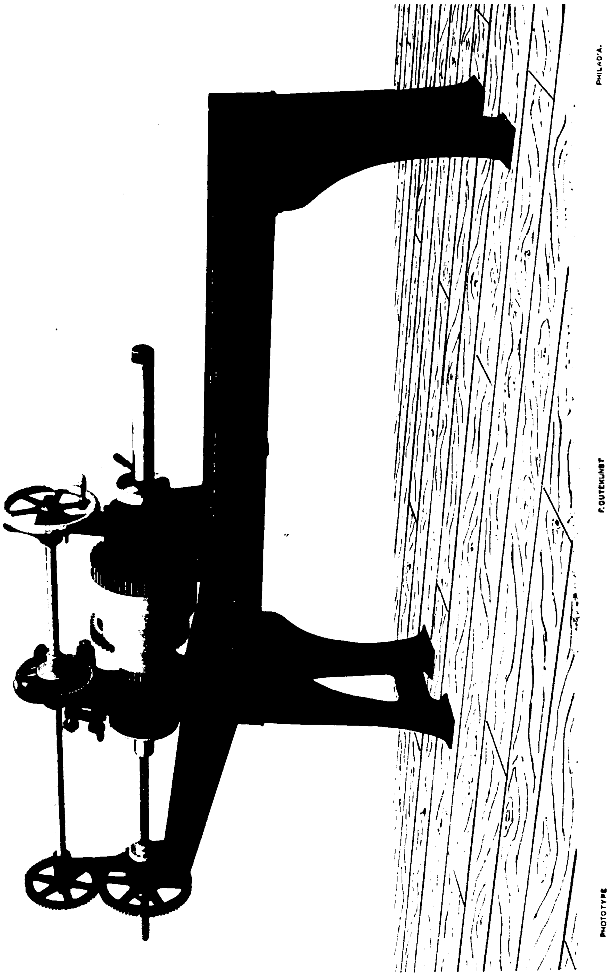
FIG. 25.



HORIZONTAL BORING MACHINE.

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HORIZONTAL BORING MACHINE.

16 INCHES SWING, WITH FIXED BED.

With improved self-acting variable feed, and quick hand traverse to the boring spindle, instantly changeable from one to the other. Feed operated from friction feed discs, permitting an infinite gradation of the feed between the limits of fastest and slowest, say from .0018 of an inch to the revolution of the spindle to .28 of an inch. Spindle of the best forged cast steel $2\frac{7}{8}''$ diameter, 30 inches stroke; spindle threaded on its outer end to receive boring-bars, or to hold specially fitted chucks. Bed with flat top as in lathes. Height of bar centre above bed 8 inches. Machine adapted to boring work held in special holders. Longitudinal slots in bed to take bolts used in securing holders to place. No adjustable table. Bed 52 inches long beyond the boring head. Iron cone pulleys turned inside so as to be perfectly balanced. Three speeds to the cone, making with the back gear six changes of speed, belt to cone pulley 4 inches wide. Over-head shaft with ball and socket hangers and fast and loose pulleys, 14 inches diameter, 4 inches face, which should make 80 revolutions per minute. Full set of wrought iron wrenches. Wrought iron work case-hardened.

No adjustable table.

THIS machine is, in principle, the same as our larger horizontal drilling and boring machine, but is not provided with any adjustable table for the work to rest on. The bed or shear extends beyond the boring head 52 inches, is 13 inches wide, and has two slots for the holding-down bolts used in securing the chucking devices to place.

Swing.

The machine as ordinarily made has the spindle 8 inches above the bed, but this distance can be increased to 10 inches if so ordered; the bed can also be made longer than 52 inches. In any case where there is a repetition of boring on the same kind of work it has great advantages. In our own establishment we use it in the brass shop, and employ it extensively in our machine shop in boring hangers, the boxes for hangers and shafting couplings. They are

Examples of its use.

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used on many of the leading railroads for boring car boxes and similar work. In the manufacture of the Westinghouse air-brake these machines are employed to bore the cylinders of the pumps, and of the air cylinders which are placed under the cars, these latter being from ten to twelve inches in diameter. For cylinder boring the great range of feed is especially advantageous, inasmuch as it enables the user to bore with a fine feed in roughing out, and gives a very coarse feed for the finishing cut; the change from one to the other being instantaneous.

Westinghouse air-brake.

Boring cylinders with coarse feed.

Fast and loose pulleys on the counter-shaft are 14 inches diameter and 4 inches face, and this shaft should have 80 revolutions per minute, giving to the boring bar the following speeds, 140, 80, 45.7, 25.2, 14.4, and 8.2; the slowest of the speeds giving about 17 feet per minute speed of cut in a cylinder 8 inches in diameter. If it is desired to bore larger cylinders than 8 inches, the speed of the counter-shaft should be decreased in proper proportion.

Speed of counter-shaft.

Speed of cut.

We have also the design of a horizontal boring machine, to be used as a drilling machine, and embodying the various features of this one, so far as its boring-head is concerned, but provided with a table adjustable vertically after the manner of the table on our vertical drill. See page 48.

Same machine with adjustable table.

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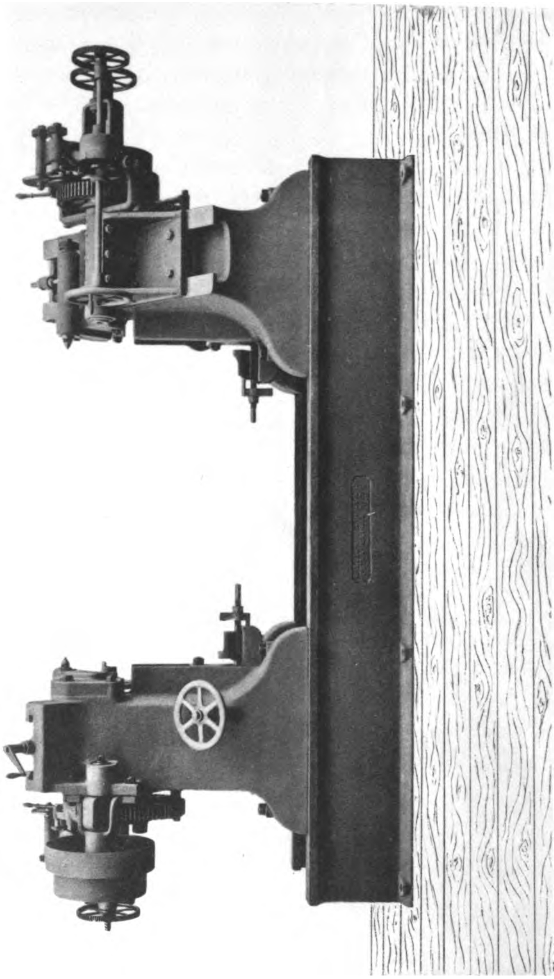
FIG. 26.



Phototype. F. Gutekunst, Philada.

WHEEL QUARTERING MACHINE.

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WHEEL QUARTERING MACHINE.

Quarters from 5″ radius of crank up to 13″, right hand crank leading. Bores both holes at the same time from the outside of the wheels. Will adjust from five feet gauge of road down to eighteen inches gauge. The wheels and axles are supported, adjusted, and secured upon tread of wheel, so as to insure great rigidity while being bored; feeds adjustable and automatic through a wide range from fine to coarse; instantaneous in their application, and yet not interfering with the quick hand motion of the spindles. Boring heads are operated independently from separate counter-shafts. All adjustments to gauge or to throw of crank being made without loss of time; absolute accuracy is obtained by long bearing surfaces, flat on top but provided with our patent under-bed V. Counter-shafts fitted with ball and socket hangers, and fast and loose pulleys 19″ diameter and 4″ face. They should make 80 revolutions per minute. Full set of wrought iron wrenches. Wrought iron work case-hardened.

THIS machine as originally made by us was arranged to quarter, either right or left hand crank leading. We now make it to quarter one way only, unless ordered to the contrary. If desired, the machine can be built to quarter either hand. It is made to take in five feet gauge as the widest, but will close up to 18″ gauge, and bore at 5″ radius and up to 13″ radius. Thus it will be seen that it takes in the entire range of engines from the smallest mine engine on a narrow gauge road up to the largest engine on the widest gauge now in use in this country. The boring spindles are outside of the wheels to be bored. They are entirely independent of each other, and are operated from separate counter-shafts. The stopping of one does not delay work on the other, each

Quarters, right hand lead.

Bores from outside of wheel.

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Feed.

being adjustable to its own requirements. The feed is of the most improved kind, as applied to all our vertical and horizontal drills, so wide in its range as to permit the use of a fine feed for the roughing cut, and a very wide or coarse feed for the finishing cut. The wheels on their axle are carried by their tread on adjustable cradles, upon which the wheels rest and to which they are firmly clamped. There are centres provided to control the position of the axle, but not to carry the weight of the wheels while they are being bored. In practice, the wheels rest on the centres until the cradles are brought up to the tread and made to carry the weight; shoes worked by adjustable screws on these cradles are then made to grasp the tread firmly to prevent the movement of the wheels while being bored, thus relieving the centres, which only serve to steady the axles sideways. This insures great stability, and entirely precludes the possibility of the wheels shifting under cut or from springing from pressure of cut.

Centres.

In order to insure great accuracy, and to do away with all liability to wear out of adjustment, the bearing surfaces are all made unusually wide and long, the clamping to place being by means of the patent under-bed V used on our slide lathes. The countershafts have 19″ fast and loose pulleys, 4″ face, and they should make 80 revolutions per minute.

Large surfaces.

The machine is not only valuable as a quartering machine, but it may be used to advantage as a horizontal drill for other purposes. The spindle has 9″ traverse.

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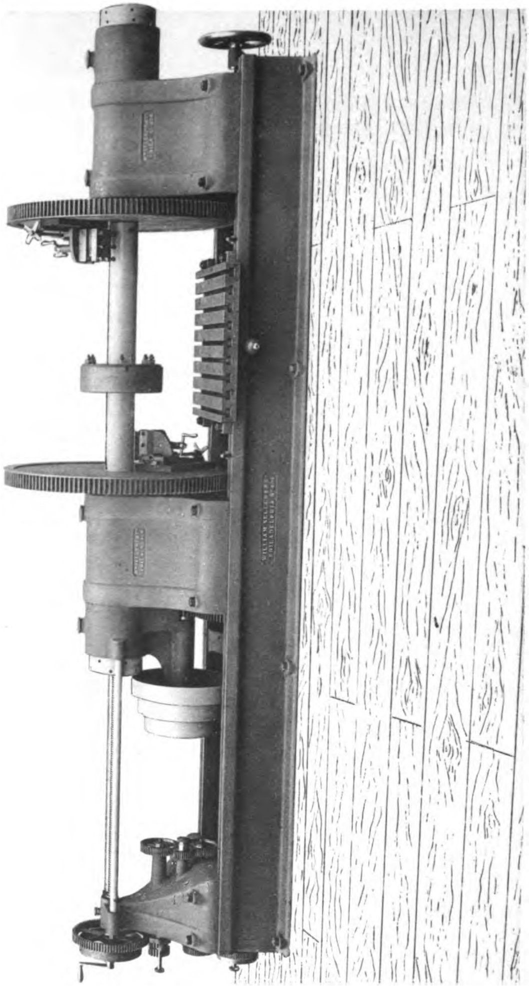
FIG. 27.



Phototype. F. Gutekunst, Philada.

CYLINDER BORING AND FACING MACHINE.

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CYLINDER BORING AND FACING MACHINE.

(*For Report of Judges, see page* xvi.)

For boring locomotive cylinders. Six-inch steel boring bar, driven at both ends of cylinder; independent slide rests for facing off both ends of cylinder; six changes of boring feed, with a quick hand feed; cutter heads to bore from 10 to 22 inches. Bar draws entirely out of cylinder by hand or power, to allow the work to be shifted. Iron cone pulleys turned inside, so as to be accurately balanced; overhead shaft, with ball and socket hangers and fast and loose pulleys, 18 inches diameter, 4 inches face, which should run 140 revolutions per minute. A full set of wrought iron wrenches. Wrought iron work case hardened.

THIS is one of the most notable of the modern special tools: it was designed to bore locomotive cylinders; and is capable of boring and facing up the flanges, also counter boring for clearance of pistons at end of stroke of a cylinder of the largest size used in freight engines or express passenger engines, in three and a half hours. This is remarkable, when the quickest time ever known to have been made in the same work previous to the construction of this machine was *nine hours:* the usual time, however, being seldom less than thirteen hours on ordinary boring machines. In performing this work the same principle is brought into play that is mentioned in our notes on Boring Mills,—one cut with a fine feed takes out the greater part of the metal. While the roughing cut is being made, the sinking head is cut off by the face plate slide rests and the flanges turned up: two finishing cuts are then run through with a feed ½ inch broad, and the cylinder counterbored at end afterwards.

Time taken on other machines.

Nature of feeds.

In case of it being deemed advisable to turn the flanges up at a time when no cut is under operation, the increase of time still permits the work to be done

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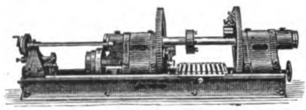
in less than five hours to each cylinder. Fast and loose pulleys on over-head shaft, are 18 inches diameter, 4 inches belt, and should run 140 revolutions per
Speed. minute. This will give speed of cut on 22 inches cylinder of 18 feet per minute.



BORING BAR FOR LOCOMOTIVE CYLINDERS.

WE also make a very convenient boring bar, to be used in a lathe, adapted to boring locomotive cylinders. The head on this bar traverses, and it has a device for cutting off the sinking heads of the casting.

In use, the cylinder is secured either directly to the lathe bed or to the saddle of the slide rest; but is not moved during the boring.

FIG. 28.

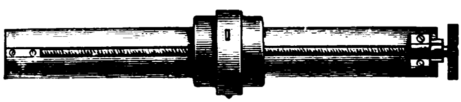


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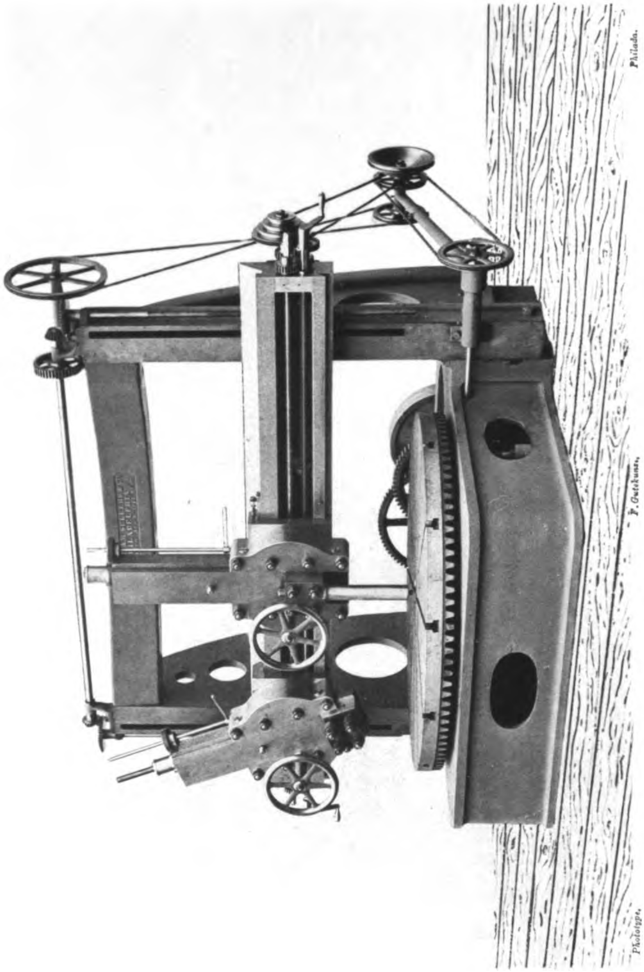
FIG. 29.



84-INCH BORING AND TURNING MILL.

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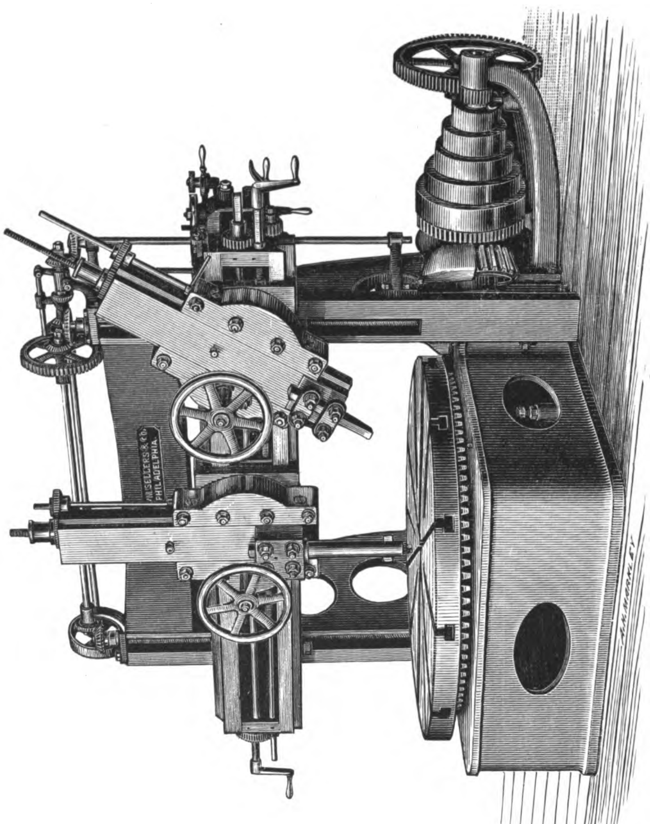
Fig. 30.



60-INCH BORING AND TURNING MILL.

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BORING AND TURNING MILLS.

THESE mills are adapted to bore with a boring bar having a double-ended cutter, or to bore with a single-pointed tool. Can be advantageously used in both boring and turning large pulleys, and in doing all work usually done on a facing lathe, with the advantage of ease of chucking, inasmuch as the face plate being horizontal, work laid upon it may be moved about until correctly centred and then clamped to place. These mills have no part of the machinery extending below the surface of the floor upon which they rest. They should be placed on foundation walls so built as to make a pit below the centre of machine, into which chips fall, to be removed at convenience. Many of them are used in locomotive shops for boring truck wheels and tire. Numbers of driving boxes also are placed in a circle on the plate and faced off at one operation in an economical manner. The feeds are so arranged as to enable the roughing cut to be made with fine feed, but the finishing cuts with very broad feed, say $\frac{1}{4}$ inch to a revolution, to prevent wear of finishing tool (which takes a light depth of cut). N. B.—This is an important item in the economical use of many of our tools.

Face plate horizontal.

Foundation.

Feeds.

A recent improvement in these mills permits the vertical slide to be fed at any angle in relation to the cross-head. We attach heavy feed rack and pinion for hand-power slotting, when required to do so.

Hand-slotting devices.

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Arranged with two heads.

We can arrange these machines with two saddles on the cross-head, when required. When so arranged only one of the heads can be taken to the centre for boring, the other head serving for turning, so that one can be used for turning, the other for boring, or both for turning. The feeds for each head are separate. We also have patterns for a convenient, adjustable centre-head, to carry pulleys on a vertical mandril while being turned. We make several sizes of these boring mills suited to heavy or light work.

Centre-head.

60-INCH BORING MILL.

This mill will turn work 60″ diameter, and has a height under the cross-head of 35″, and under the saddle a height of 33″. The vertical slide has a movement of 22″. The cone pulley is not at the back of the machine, as on the larger sizes, but to the right hand of the workman when facing the front of the cross-head. The pulleys are so placed that the cross-head of the machine is parallel with the line-shaft of the shop. Fast and loose pulleys on the counter-shaft are 20″ diameter, and should make 110 revolutions per minute. Diameter of face plate 59″.

66-INCH BORING MILL.

This mill will turn 66″ diameter. In other respects the description of the 60-inch mill applies to this size.

84-INCH BORING MILL.

See page 92, Fig. 29.

We make this size of boring mill with high or low uprights. Height under the cross-head of the low one 43¼″, and under the saddle 40″, while with the high uprights the corresponding dimensions are 81″

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and 78″. In other respects the machines are alike. Fast and loose pulleys on the counter-shaft are 22″ diameter and 7″ face, and they should make 90 revolutions per minute. Vertical slide moves 22″.

120- AND 144-INCH BORING MILLS FROM 84-INCH MILL PATTERNS.

We can widen the 84″ mill to take in ten or twelve feet, fitting these mills with high uprights, so as to clear 78″ under the cross-head of the 120″ mill, and using a much heavier cross-head than is required on the 84″ mill; the table is made 80″ diameter; on the 144″ mill height under cross-head is 75″; in other respects the machines are alike. Counter-shaft for the 120″ mill same as for the 84″, and speed the same also; but for the 144″ inch mill the counter-shaft should make 180 revolutions per minute. **Heavy cross-head.**

N. B.—We can arrange these large mills with bevel gears at the back of the bed, so as to place axis of cone pulley-shaft parallel with the cross-head. This also increases the belt power, and enables us to apply triple gearing with fifteen changes of speed. **Triple gear.**

EXTRA HEAVY 144-INCH BORING MILL.

This is a new design of mill, intended for very heavy work, and has a greater height under the cross-head,—viz., 92″, and a height under the saddle of 87″. The table is 108″ diameter. The vertical slide has a movement of 36″. It has triple gears, giving fifteen changes of speed. The counter-shaft, fast and loose pulleys 22″ diameter and 6″ face, which should make 148 revolutions per minute. **Speed.**

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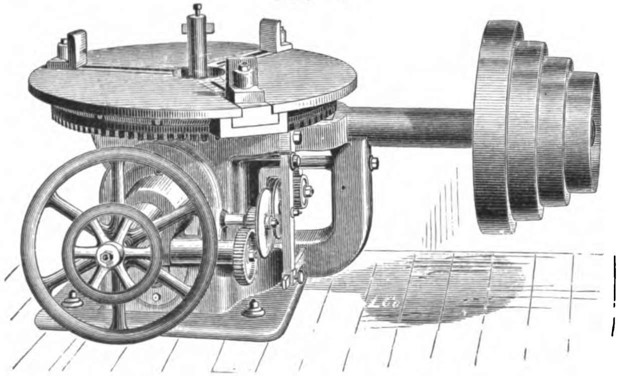
FIG. 31.



PATENT BORING MILL.

For car wheels and general work, fitted with universal chuck for all sizes up to 36 inches diameter, and capable of boring driving wheels 6 feet in diameter; cross head for holding boring bar counter-balanced and arranged with power feed and quick hand traverse in either direction; the sliding surfaces always clear of chips, which can fall through the face plate as in mills where the bar is supported above; with over-head shaft, iron cone pulleys turned inside so as to be perfectly balanced; ball and socket hangers, and a full set of wrought iron wrenches. Wrought iron work case hardened.

THIS is a useful tool for boring only; is adapted to bore car wheels up to 36 inches in the chuck on the face plate: will bore a wheel six feet in diameter. It uses boring bars with double-ended gib cutters only, the bar being carried by a cross head

Size of bar. below the table. The bar must be small enough to pass through the hole in wheel before it is bored. Counter-shaft has 24 inches by 4 inches fast and loose

Speed. pulleys, which should make 60 revolutions per minute; bed of machine must rest on foundation walls, allowing part of the guides for cross head to extend below level of floor.

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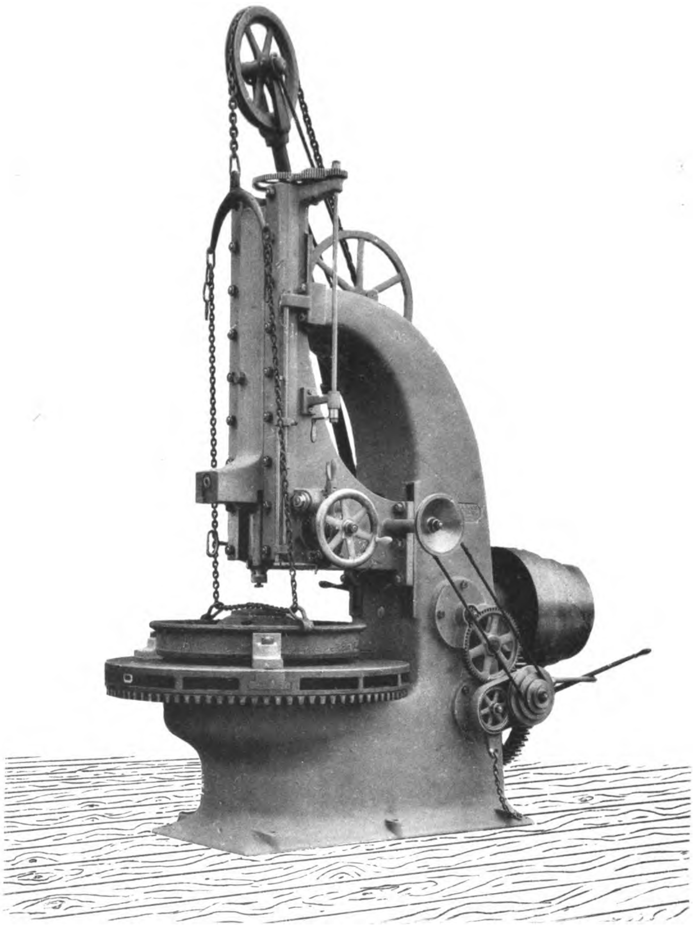
FIG. 32.



CAR WHEEL BORING MILL.

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CAR WHEEL BORING MILL.

For car wheels, and general work up to 50-inch diameter. Boring bar operated from above; the bearing for bar adjusted vertically. The vertical slide holding boring bar counter-balanced and arranged with power feed and quick hand traverse in either direction. The revolving table arranged with universal chuck for all sizes up to 36-inch diameter. Special jaws for 42-inch wheels furnished when ordered. In addition to the boring machinery, an adjustable *Hub Facing Attachment* is provided, the slide of which is at the lower end of boring slide; can face up the entire hub or turn a narrow face for car wheels. Over-head shaft with ball and socket hangers and iron cone pulleys turned inside, so as to be perfectly balanced; full set of wrought iron wrenches. Wrought iron work case-hardened. Two sets of fast and loose pulleys on counter-shaft, one pair 24 inches diameter for 4-inch belt, which should make 120 revolutions per minute; the other pair, 12″ x 4″, which should make 260 revolutions per minute.

THIS machine, called also 50-inch Boring Machine, has same face plate, chuck, and means or method of driving as our Patent Boring Mill; but the boring bar is forced down from above into the wheel being bored, and may be larger than in the case of our Patent Mill, Fig. 31. This machine is more efficient, also, and has the advantage of being able to turn off the faces of hubs of locomotive truck wheels. To it we adapt a patent safety crane attachment when desired, operated by power. In boring cast iron car wheels, it is customary to take out the bulk of the metal to be removed, by a double-ended cutter in the boring bar, at one operation, and with a fine feed; then to finish with a very coarse feed, taking out but little metal. This hurrying through of the finishing tool, with but little work to do, insures uniformity of size of hole.

Crane attachment.

For speed see specification above.

Capacity of work may be stated as 50 car wheels in 10 hours.

Capacity.

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MEMORANDUM FOR BORING CAR WHEELS.

Speed of cut.

In boring car wheels, assuming the usual size eye, viz., $4\frac{1}{8}$ inches diameter, $6\frac{1}{2}$ inches length of hub, with a core $3\frac{3}{4}$ inches diameter, the mill should be run at a speed that will give (12) twelve turns per minute to the wheel, thus making speed of cut about 13 feet per minute. The roughing tool should bore the hole $4\frac{3}{32}$ inches, leaving $\frac{1}{32}$ inch for the finishing cut. The speed of the feed on roughing cut should be 8 to the inch; each end of the cutter having $\frac{1}{16}$ inch feed. At this rate, the roughing cut can be run through in $4\frac{1}{3}$ minutes. The finishing cut should have not less than $\frac{1}{4}$ inch feed, running its cut through in a little over 2 minutes. The two cuts should take $6\frac{1}{2}$ minutes, or 7 minutes at the utmost. The number of wheels bored per day will depend upon the quickness of the man changing the cutters and shifting the wheels; allowing 5 minutes for changing cutters, facing off hubs, and shifting wheels, 50 wheels should be bored every 10 hours.

Number of wheels bored.

Example of work done.

At Messrs. A. Whitney & Sons' works, their regular day's work is 60 wheels in 10 hours; but on a trial of speed, one man bored 100 wheels on one mill in 10 hours, or one every 6 minutes. To do this he ran the mill faster than usual, making the cutting speed about 18 feet per minute, and finishing on a feed of $\frac{3}{8}$ of an inch.

Shape of cutters.

The cutters are always made double ended, and are turned up square to begin with, thus:

FIG. 33.

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but as they become dull they are ground off into a shape, thus:

FIG. 34.

and are said to work better after the cutter has begun to be oblique. The finishing cutter, having but little to do, does not wear away very rapidly; in fact, its deterioration depends more upon the time taken to run it through the wheel, than upon the amount of metal removed by it. A fine feed on the finishing cut wears the cutter more than a quick one. The coarser the feed, within reasonable limits, the longer the cutter will remain to size. **Coarse feed for finishing.**

The fast or roughing cut will require the cutter to be ground up for every 4 or 5 wheels. The finishing cutter used as above—i.e. with $\frac{1}{64}$ of an inch cut on each end, $\frac{1}{4}$ of an inch feed—will last for 50 wheels with no appreciable change in size. Sometimes cutters have been found that would size 250 wheels with no deterioration. They are always made soft in the middle and hard at the cutting ends. As soon as they show any wear they are stretched to length by paning the soft part in middle of cutter with a hammer. The gauge used for testing the size of bore is a piece of steel like a cutter, made of 1 inch by $\frac{3}{8}$ of an inch steel, ground to the proper size after hardening, thus, rounded to fit the hole narrow way of the ends, so as to be inserted edgeway: **Durability of cutter.** **Gauge.**

FIG. 35.

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Size of axle in "fit."

Axles are turned about .007 of an inch larger than the bore of wheel; with the difference of size the force required to push on the wheel is from 20 to 30 tons, and the wheel will not come loose in use.

GRINDSTONE BOXES.

With shaft and ball and socket bearings complete; the whole fitted to run upon wheels. Pulleys and grindstones extra.

To swing 42-inch stone 6-inch face.
" " 48 " " 7½ " "
" " 60 " " 8 " "

THESE boxes are of cast iron, in one piece, resting on three wheels, one of which is made to turn in a socket, for ease of moving the box to place. This arrangement permits the box to be run under a crane for putting stones in place, and when placed in proper position, the front wheel being turned at right angles to the others, holds the box stationary against the pull of the belt, at the same time, by moving the box, permitting the same belt to be used, without cutting, for large and small driving pulleys as the stone wears down and requires speeding up. When required to furnish pulleys, we select such sizes as will in use keep the stone up to speed as it wears. We also make an arrangement with wrought iron tank for 72-inch grindstones.

Tank for 72-inch stone.

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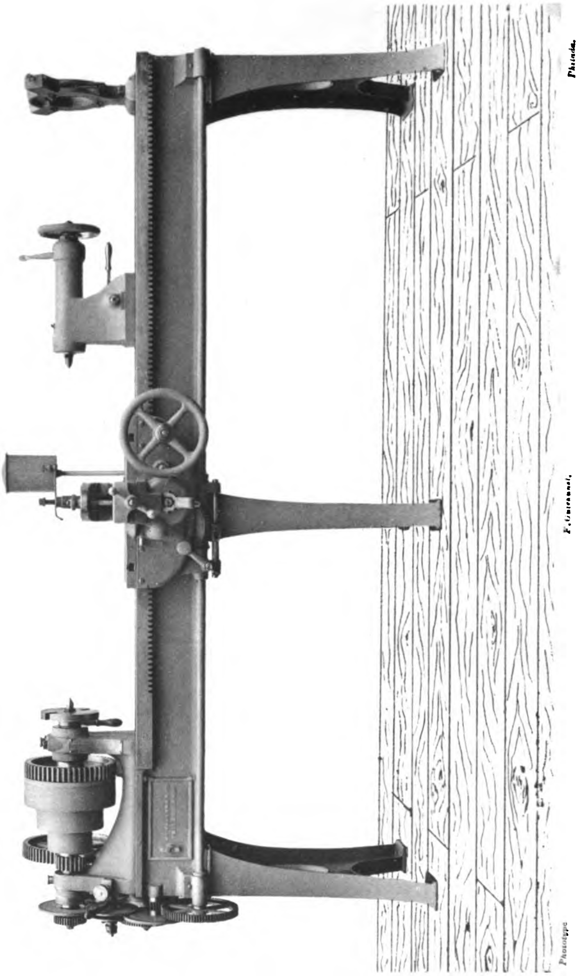
FIG. 36.



16-INCH SELF-ACTING SLIDE LATHE.

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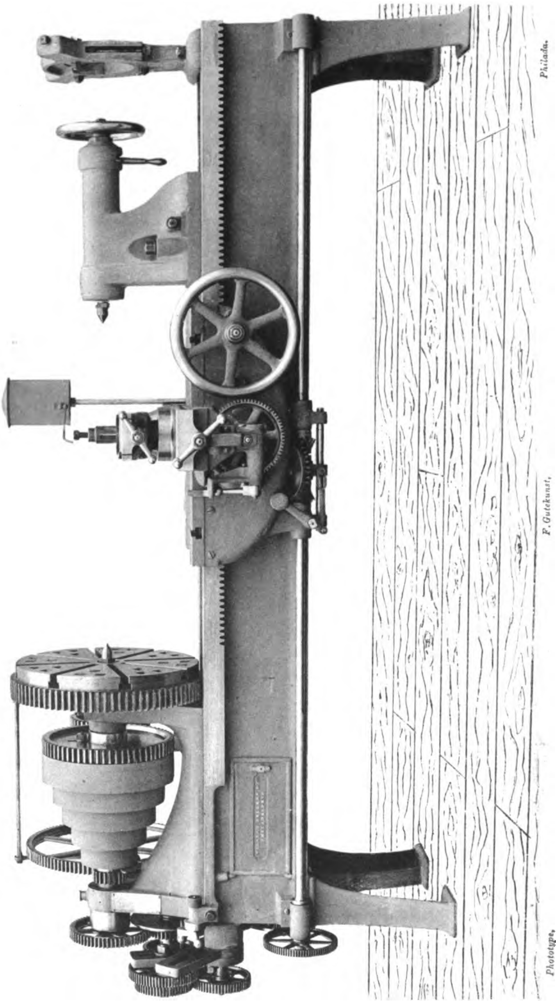
FIG. 37.



25-INCH SELF-ACTING SLIDE LATHE.

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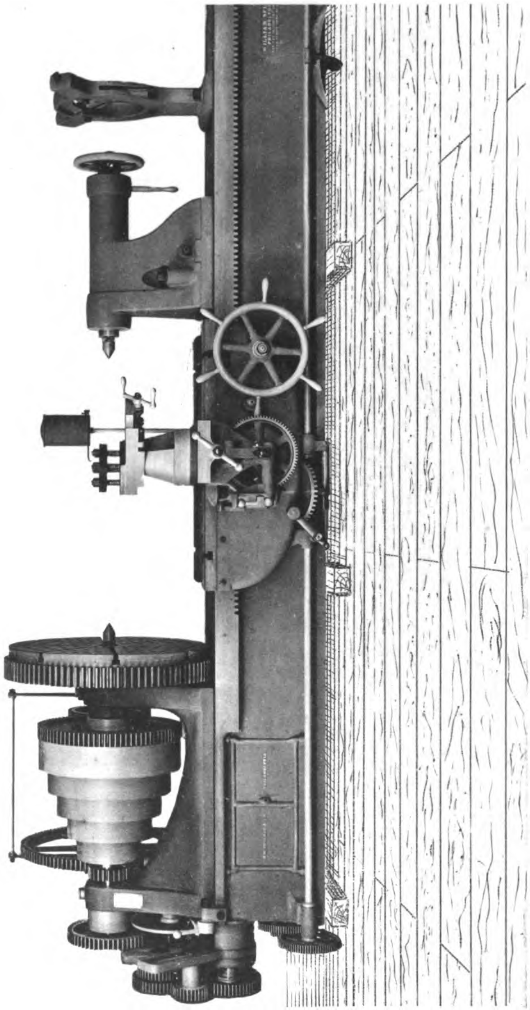
FIG. 37A.



Phototype. F. Gutekunst, Philada.

48-INCH SELF-ACTING SLIDE LATHE.

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PATENT SELF-ACTING SLIDE LATHES.

Beds flat on top with vertical guiding surfaces, with improved hold-down for the poppet head, insuring the centre being in line with the axis of the live spindle; concentric hold-fast to the spindle of the poppet head, *clamping the spindle at both ends of its bearing.*

FOR 48 INCHES SWING AND UNDER.

Independent screw-cutting and turning feeds, so arranged as to be instantly changed from one to the other, when both are in gear with the spindle; either screw-cutting or turning feed when in gear stops the other one from being put into gear; turning feeds adjustable to any rate between the fastest and the slowest; change in the direction of the turning feeds made by the motion of a lever in convenient position; stopping and starting of the turning feeds instantaneous, and so arranged in those lathes having cross feed as well as longitudinal feed as to preclude the possibility of mistake as to which feed to apply; lead screw is used for screw-cutting only, and is supported over its entire length; spindles are made of the best cast steel forgings, the live spindle running in special bronze bearings.

Lathes of 12 and 16 inches swing, back geared, affording six changes of speed, wide belt on the cone. Turning tool has a vertical adjustment on a single slide rest. Lathes of 20 inches swing are back geared, with eight changes of speed, and wide belt to the cone. Lathes of 25 inches swing and up to 48 inches swing, inclusive, are triple geared, affording fifteen changes of speed in geometrical progression. Lathes of 20 inches swing and up to 48 inches swing, inclusive, are provided with compound rests, and have cross feed in addition to the longitudinal turning feed, the use of either feed being free from any complicated adjustment or possibility of confusion. Steady rest; overhead shaft with ball and socket hangers and iron cone pulley turned inside so as to be perfectly balanced; wrought iron wrenches; wrought iron work case hardened; beds of any required length.

LATHES OF OVER 48 INCHES SWING.

With cast iron spindles, the cone pulley and back shaft driving through the face plate only, with fifteen changes of speed. Independent screw-cutting and turning feeds, so arranged as to be instantly changed from one to the other, when both are in gear with the spindle; either screw-cutting or turning feed when in gear stops the other one from being put into gear; turning feeds adjustable to any rate between the fastest and the slowest; change in the direction of the turning feeds made by the motion of a lever in conven-

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ient position. These lathes are provided with power feeds for longitudinal traverse of saddle; for cross feed of lower slide; and also for angular feed for top slide. The stopping and starting of the turning feeds are instantaneous, and so arranged as to preclude the possibility of mistake as to which feed to apply; lead screw is used for screw-cutting only, and is supported over its entire length. Bed with three flat surfaces for the saddle, so arranged as to receive the pressure of the cut within the bed surface; rack movement for shifting the poppet head.

Self-Acting Slide Lathes.

Name of Lathe: that is, Diam. of Piece will swing clear of Bed.	Diam. will swing over Rest.	Distance from Centre to Centre of Girts.	No. of Girts beyond Live Head.	Distance between Centres.	Total Length of Bed.
12″	8⅝″	10″	4	2′ 4″	4′ 7¾″
16″	11¾″	13″	4	3′ 0″	5′ 10¼″
20″	15¼″	16¼″	4	3′ 8½″	7′ 4″
25″	19¼″	20¼″	4	4′ 6¾″	9′ 0⅛″
30″	23½″	24⅛″	4	5′ 5½″	10′ 8⅞″
36″	28⅝″	29″	4	6′ 7½″	12′ 10½″
42″	34½″	33¾″	4	8′ 6¾″	14′ 11¾″
48″	38½″	38½″	4	8′ 10″	17′ 0¾″
60″	49″	28″	6	9′ 1¼″	17′ 3⅛″
72″	57½″	31⅛″	8	10′ 0½″	19′ 9¾″

Speeds of Counter-Shaft for Turning and Screw-Cutting Lathes.

Name of Lathe: that is, Diam. of Piece will swing clear of Bed.	Rev. Under Cut.	Rev. Running Back.	FAST AND LOOSE PULLEYS.			
			Diameter.	FACE.		
				Loose.	Fast.	Loose.
12″	200 Rev's.	320 Rev's.	8″	6″	6″	6″
16″	143 "	286 "	9″	6″	6″	6″
20″	112 "	224 "	10″	6″	6″	6″
25″	135 "	270 "	14″	7″	7″	7″
30″	110 "	220 "	16″	7″	7″	7″
36″	100 "	200 "	20″	4″	7″	4″
48″	90 "	180 "	26″	6″	12″	6″
60″	140 "	280 "	16″	7″	7″	7″
72″	122 "	244 "	20″	8″	8″	8″

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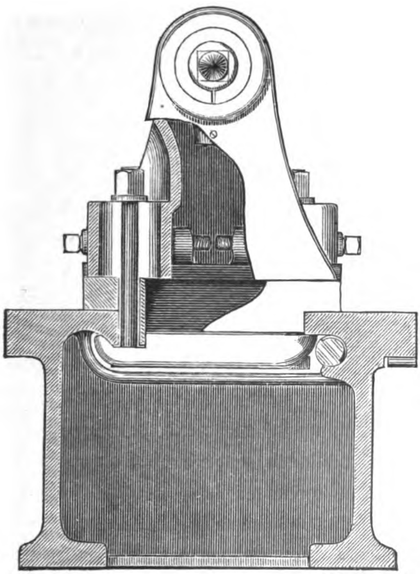
RECENT important improvements in our self-acting slide lathes call for a description of the changes made and a statement of the advantages gained thereby.

FIG. 38.



BED OR SHEAR.

In reference to the bed or shear, we uniformly make what is known as the flat-top shear, not the V shear. We adopted this form of lathe bed believing it to possess many advantages, not the least of which **Flat-top shear.**

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is, that by its use we are enabled to obtain a greater capacity of swing over the slide rest than is possible with the ordinary V shear. Recognizing the difficulty of insuring accuracy of alignment of the fixed and the movable heads, when the latter is guided by the inner edges of the opening in the centre of the shear surface only, we added a V to the under side of one of these edges. This V is made use of to hold the poppet head up to one of the straight sides of the opening in the centre of the lathe shear, when the head is clamped fast, and yet permits absolute freedom of motion when it is loosened for adjustment to place.

Greater swing over slide rest.

V on under side of shear top.

When the outside guiding edges of the flat-top shear are bevelled at an angle inclining inwards from the face of the shear as is customary, and these angular faces made to receive the holding-down shoes or gibs of the slide rest, there arise complications which it is desirable to avoid. In the first place, the wearing down of the top surface of the shear not only loosens the fit of the slide rest at the worn part (even if there is no wear on the guiding edges), but permits the movement of the slide rest sideways to the extent of this looseness; thus producing a greater disturbance of the tool line than is due to the mere change of position vertically, at the circumference of the work being turned. It also necessitates the entire readjustment of all the surfaces as soon as the lathe shows deviation from truth in turning, no matter whether the wear be on the horizontal surface or on the edges of the bed; wear on either part producing the same effect on the work done in the lathe. By making the guiding edges of the top of the shear at right angles to the horizontal plane of the shear top, that is to say, by making them vertical and not inclined, we separate the com-

Improvement in shape of edges of the bed.

Evil arising from bevelled edges.

Square edge to guiding part of bed.

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ponents of the adjustment, and cause each to be independent of the other. It has been demonstrated to our entire satisfaction, that in the case of the flat-top shear, the wear from long use occurs on the flat upper surface to a much greater extent than on the guiding edges of the bed against which the gibs press, this to such an extent as to warrant us in saying that the wear on the edges is practically of little moment, and is not perceptible after years of use. By making the edges of the shear vertical, the pressure to produce wear is diminished, and any wear of the upper flat surface does not loosen the slide rest sideways, so that the error in the truth of the turned work, due to the wear of the flat-top surface of the shear, is confined to the almost imperceptible effect of the slight difference in the vertical height of the tool while under cut, and is not complicated with any side movement of the cutting tool. A very considerable wear on the flat surface must occur before its influence can be felt on the work; while on the other hand, when the guiding edges are made inclined, a very slight wear of the top surface produces an immediate effect on the truth of the work as detrimental, as if the guiding surfaces had worn out of truth. The substitution of the vertical guiding surfaces for the usual inclined surfaces is as important to the correct working of the lathe and to its durability as was the introduction of the under V to the holding of the movable head in adjustment to the live spindle.

Wear on top of bed.

The combination of the two improvements in the flat-top system, viz., the under V and the vertical guiding surfaces, gives us a theoretically perfect lathe bed.

Inasmuch as the important improvements we have

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made in the lathe beds have removed the objections raised against the flat-top shear by those who have known the system only as in use without these improvements, we dwell upon it, the more fully to explain some of its advantages.

In view of the well-known fact that durability of machinery is largely dependent upon extended surface, where surfaces move or slide one on another, it is rather surprising that the flat-top shear should have met with so little favor in this country up to quite a recent period. Theoretically, it presents the largest wearing surface, and is the most easily made.

Saddle made thinner.

The saddle of the slide rest, bearing over its whole under surface, may find a support up to the edges of the centre opening of the shear. Having less distance to span unsupported than on the V shear, the saddle can be made thinner and yet of sufficient strength, thus increasing the capacity of the lathe swing over the slide rest. On lathes with V guides there are usually four of these guides, the two outer ones serving as guides for the saddle, and the saddle must, of necessity, span the entire space unsupported from one V to the other; hence it must be thicker and heavier than if resting on a plane surface. The nominal capacity of any lathe is what it will swing over the shear.

Nominal capacity of a lathe.

The actual capacity in relation to cylindrical work is what it will swing over the slide rest; hence the advantage of less thickness in the saddle, if of sufficient strength.

Those workmen who have not used lathes with flat-top shears are apt to think that the extended surface in contact with the shear may make it hard to move. If it be allowed to stick fast with gummy oil, this may be so; but with such care as any machine-

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tool should receive at the hand of the workman, it is really easier to move. Friction being dependent upon weight, not surface, the flat-top shear, owing to the extended bearing surface, will permit the use of much lighter saddle, and the dust and dirt are no more apt to catch upon the flat shear surface than on the V shear, and are as effectually pushed off by the saddle. Lightness in the slide rest becomes of great moment on lathes of large capacity, and is worth considering in all lathes, when it can be obtained without loss of strength.

Friction depends on weight.

Makers of engine lathes, who still adhere to and recommend the V shear, build their lathes for turning car axles with a flat-top shear. The axle lathe, but for the extended surface on the flat-top shear, would soon wear hollow at the place where most work is done. The advantages to be derived from the use of the flat-top on the axle lathe should recommend its adoption on other styles of lathes.

Facility of construction.

The flat-top shear can be readily planed true on its upper face, on its outer edges and on its inner edges. The outer edges guide the saddle, lost motions being taken up by shoes or gibs. The lathe heads are guided by the inner edges. The parallelism of all these edges can be readily insured.

Guide for back head.

Function of the shears.

The function to be performed by the lathe shears or bed is to maintain the driving head or live head spindle in line with the poppet head spindle, and to carry the cutting tool parallel with this centre line. It must do this under various conditions of strain. Screwing up the centre to hold the work tends to bend the shear in one direction. The strain of the cut tends to bend it in another, in fact, in several directions.

Twisting of shear under cut.

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It must be borne in mind that the lathe centres, being above the shear, and dependent entirely on the stiffness of the shear for their rigidity, are placed at some disadvantage in regard to leverage. A clear idea can be obtained of resultant strains if thought be directed to a lathe with a rigidly fixed live head and a very flexible shear. The work, being also rigid, will be driven around its axis by the rotation of the live head spindle, and will therefore tend to turn the slide rest, the shear and the poppet head around the axis of rotation, thus producing a severe torsional strain on the bed. Hence the bed must resist strain in all directions; the longer the bed the more elastic it would be in regard to torsion, an evil to be corrected only by the system adopted by us of introducing cross girts in all our lathe beds. These cross girts, from the peculiar construction of our lathes, extend near to the top of shear, and form inflexible ties between the two I beams, which represent the sides of the shear. The lead screw in screw-cutting lathes is placed within the bed, and, supported over its entire length by resting in a trough planed out to receive it, it is not subject to deflection; maintaining its right line will produce a truer thread, than if unsupported, except by the nut and end-bearings. By being placed under the shear top, it is entirely protected from falling chips and dirt.

Cross girts.

Lead screw in trough.

SLIDE REST WITH IMPROVED TURNING FEED.

The next important improvement in our lathes to which we call especial attention relates to the Slide Rest and the peculiar turning feed, both as regards construction and operation. In all lathes of all capacities we arrange a turning feed, quite inde-

Turning feed independent of screw-cutting feed.

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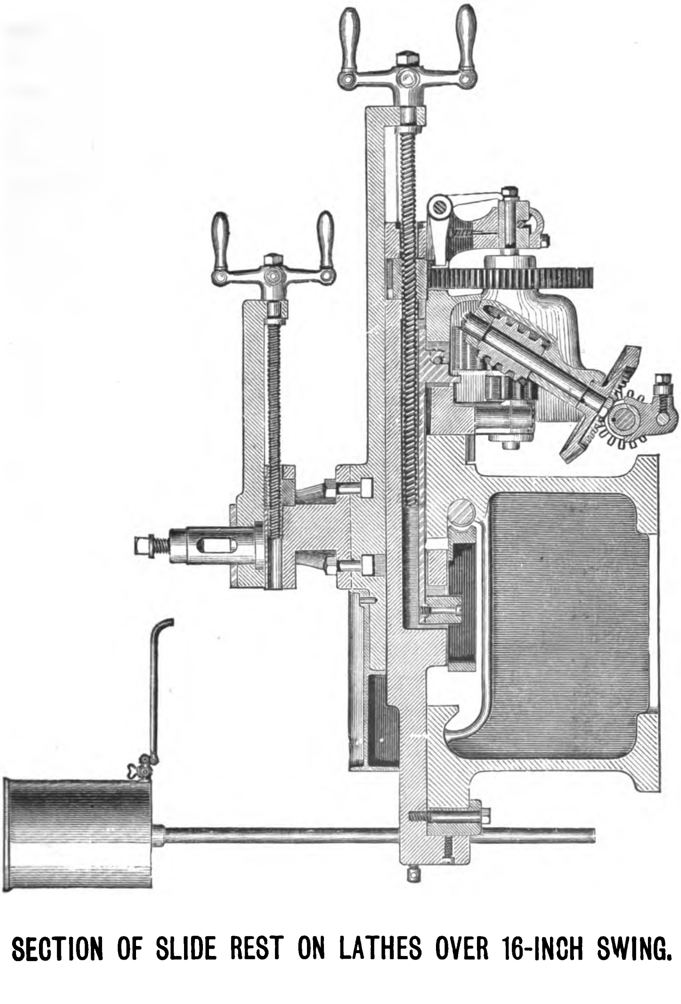
FIG. 39.



SECTION OF SLIDE REST ON LATHES OVER 16-INCH SWING.

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pendent of the screw-cutting feed, and we use the lead screw, which operates the screw-cutting feed for screw-cutting only. The turning feed is driven by a rotating feed rod or shaft running the entire length of and in front of the bed. This feed rod gives motion to the slide rest by means of a rack and gearing, the rack being on the under side of the overhanging edge of the top of the shear on its front side, while the gearing is carried by the apron dependent from the front side of the slide rest. In place of the shifting right and left hand worms on the feed rod, gearing into one worm wheel, to operate both directions of feed, as usually employed in American lathes, we introduce a novel motion obtained from bevel wheels on the feed rod, and carried through a system of gears, one of which is our spiral pinion motion to the pinions which work the feeds; either to that one which operates the longitudinal feed and gears into the rack, or to the pinion on the screw of the cross slide to operate the cross feed. A weighted ended lever near to the lower edge of the apron of the slide rest can be tumbled over by the slightest touch, carrying with it the clutch which gives motion in the required direction, and the motion of this lever is such as to coincide with the direction of the feed; thus, if the lever be thrown over to the right the lathe will feed in that direction, and if to the left it feeds to the left. In lathes provided with a cross feed in addition to the regular feed, a lever, limited in its motion by a shifting stop, controls the starting and the stopping of the feed in use. The position of this stop determining the character of the feed to be used.

See Fig. 39, page 117.

Device for shifting the direction of feed.

See Fig. 40, page 119.

See page 108.

Motion of the shifting lever coincides with direction of feed.

Cross feed.

The cross feed is obtained by turning a revolving nut in the lower slide rest, and this revolving nut when

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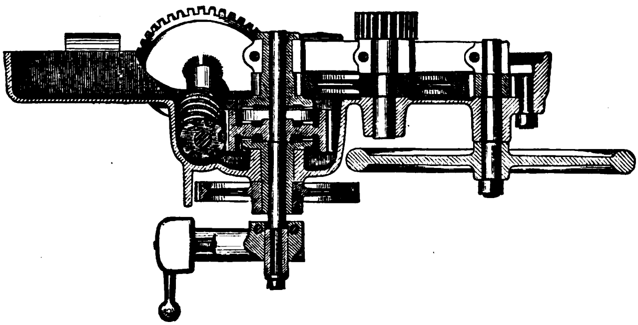
not in use for an automatic cross feed must be locked to place and so made a stationary nut. One of our marked improvements is in reference to this locking and unlocking of this revolving nut. This part is

FIG. 40.



made self-adjusting, and is part of the movement of setting the required feed, so that all complication of movements to arrange for the feed required is done away with. Too much stress cannot be laid on this part of the machine, for, apart from the saving in diminished friction, due to the dispensing with the worm and wheel, the great saving in time alone, effected by the exceedingly simple and certain system of movements requisite to control the various motions essential in a self-acting slide rest, is an important consideration, as every motion in our new system is instantaneous. We have also added a very efficient device to prevent the screw feed and the turning feed being thrown into gear at the same time.

Screw feed and turning feed cannot be in gear at same time.

The feed rod on our lathes is driven by our well-known friction feed discs, and these have been improved both in their range and in the method of

Feed discs.

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clamping to position, and yet permitting quick and easy adjustment. We also indicate at the point of adjustment the approximate feed obtainable at any fixed position of the movable discs. This is quite important, as it enables the workman to set the feed coarse or fine with certainty without any trial.

Compound rests on lathes of 20″ swing and over.

Lathes of 20-inch swing and over have two slides to the rest, the upper one being swivelled to set at any required angle in boring or the like work, and the stand below the upper rest is graduated to facilitate this setting. The slides are all so arranged as to entirely cover the bearing surfaces upon which they slide, so as to effectually exclude the dirt from all these surfaces. Our 12- and 16-inch lathes have an adjustable device for setting the point of the tool high or low after it is clamped to position. This is a very important feature and greatly increases the efficiency of the lathe, inasmuch as such lathes are used on work of small diameter, and the smaller the piece being turned the more care must be exercised in setting the tool as to height of the cutting point. As these smaller lathes have no cross feed worked automatically, we arrange a lever and latch in a convenient position below the cross slide to stop and start the feed. Our aim has been to arrange all the operating levers of the slide rests in such position as to be very convenient to the workmen, and to be so readily operated as to consume neither time nor attention. For all lathes of 36 inches swing and under we use the single screw tool post, but on lathes of greater size we place on the top rest four standing bolts, and with these hold clamp-plates or bars, admitting of great firmness of holdfast and permitting a wide range in tool position.

Adjustment of height of tool point.

Convenience of the arrangement.

Tool post.

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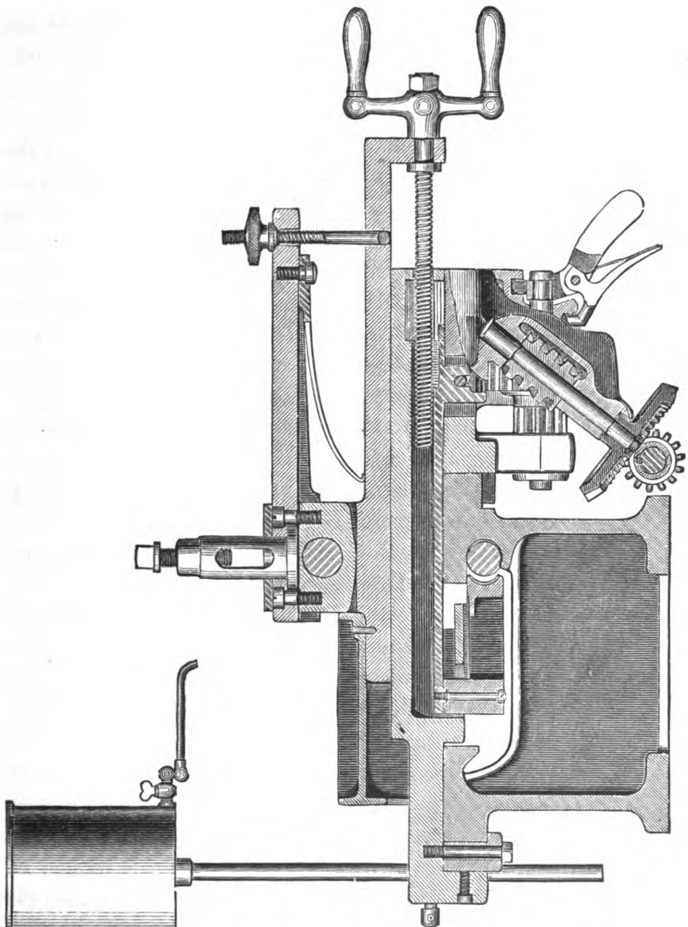
Fig. 41.



SECTION OF SLIDE REST OF 12-INCH AND 16-INCH LATHES.

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MOVABLE OR POPPET HEAD.

V on under side of flat-top shears.

In regard to the movable or poppet head of the lathe, we have already mentioned its insured alignment by means of the V on the under side of one of the inner edges of the flat top of the shear. When the head is loosened for adjustment back and forth on the bed it is free to move, but the moment an attempt is made to tighten it to place this under V, acted on by the clamping-down shoe, draws the head over to one side of the centre opening in the shear and holds it firmly against this surface, which surface is subjected to no wear whatever. The practical utility of this important feature of our lathes has been demonstrated through many years of constant use. Our more recent improvements in the poppet head relate to the concentric clamping of the sliding spindle at both ends of the bearing in which it slides. We arrange a lever convenient to the wheel, which works the screw in the spindle; a simple motion of this lever clamps the spindle concentrically at both ends of its bearing, and with a uniform pressure at each end. The concentric clamping device at the nose of the poppet head bearing, which has been in use for some time, while being an improvement over the old clamping set screw, does not hold the spindle with sufficient rigidity, inasmuch as it leaves it free to move out of line to the extent of any looseness in its bearing back of the clamping device. By clamping at front and back and of the bearing we obtain great rigidity of alignment, and yet permit freedom of motion when the spindle is loosened. We also thereby render the spindles of our poppet heads interchangeable, thus adding another item to the list of interchangeable parts to the

Concentric clamping.

Renders the spindles interchangeable.

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Fig. 42.

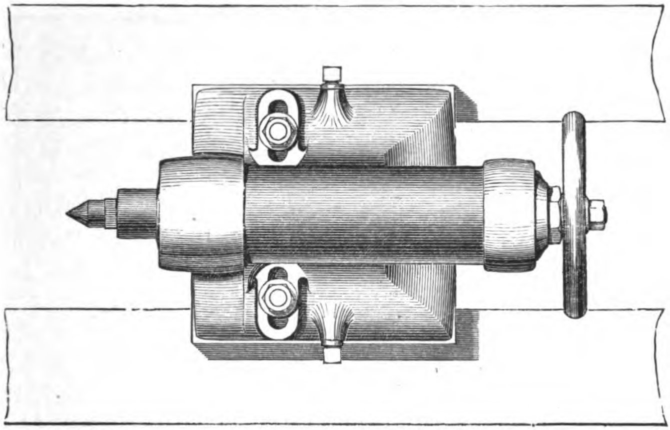
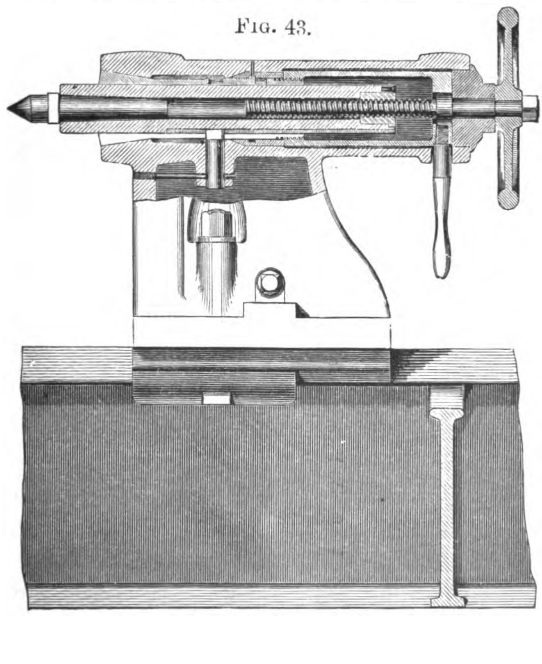


Fig. 43.



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system. It has been our constant aim to render all parts of our machine tools interchangeable, but in the case of the spindles of the poppet heads of lathes, so long as their rigidity depended upon accuracy of fit to any considerable degree this was impossible. The introduction of the double concentric clamping device above alluded to accomplishes the much desired possibility of interchange in the parts, and it also gives more freedom of motion when the spindle is freed from its clamps.

Turning tapers.

If lathes were not required to turn tapers as well as cylinders, there can be no doubt that the poppet head, made in one piece, resting on the shears over a sufficiently broad surface and capable of adjustment sideways only to the extent of practical alignment, would be the simplest and the best. In our own practice we prefer this system, and, while we make our poppet heads in two pieces so as to be capable of being set over to turn tapers, we adapt to lathes requiring it a device which enables the turning tool to be guided by former bars, and thus to produce tapers or irregular shapes, such as the curves of handles, etc.

Former attachment.

This device, called technically "a former attachment," does much better conical or tapered work than with the centre set over out of line, for reasons obvious to all mechanics familiar with the use of the machine, and gives a greater range to its capacity.

How to line centre.

We may be pardoned for mentioning in this relation what we consider the readiest method of bringing the centre in line after the head has been set over, in adjusting the centres in the first place or in testing the correctness of a new lathe. A bar of round iron carefully centered, is turned up a short distance on one end. This turned end being placed next to the live head centre, a turn-

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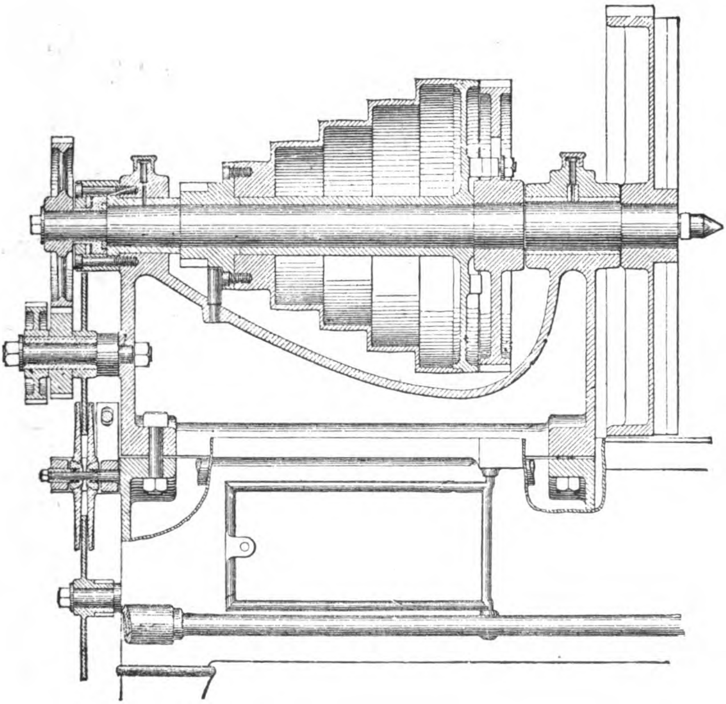
ing tool clamped in the slide rest is made to just touch the turned part. Taking out the bar the tool is then moved over to the poppet head spindle, and the bar reversed with its turned end next to poppet head centre, when, if the tool just touches the turned part as before, the lathe may be considered in adjustment.

FIG. 44.



LIVE HEAD.

Especial attention has been bestowed on the design of the Live Head, and the greatest care is taken in the

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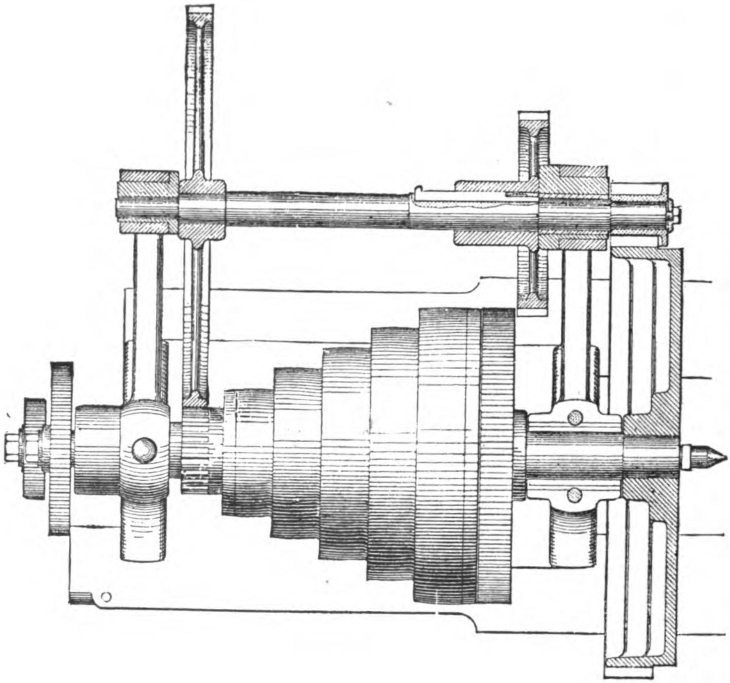
FIG. 45.



perfection of the workmanship on all its parts. The possibility of turning a true circle depends on the accuracy of the spindle, for its shape is reproduced in turning, and truly cylindrical work can only be produced when the spindle is truly round. To do good facing work the spindle must be insured against end motion, and the cross slide of the slide rest must be at right angles to the spindle. Theoretically, a hardened steel spindle running in hardened steel bearings, the spindle and its bearings having been made true

Turning true circles.

Facing work.

Hardened steel spindles.

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after they are hardened, would seem to present the most reliable conditions of correctness and durability. Such spindles, however, are expensive, and, unless well looked after, are liable to cut and stick fast, so that carefully-made spindles of the best cast steel forging, not hardened, running in special bronze bearings, are preferred. We do not collar the front end of the spindle, but we make the journal of good diameter and length, taking care to have it truly cylindrical, and we support it over its entire length in a truly cylindrical bearing of a carefully prepared bronze. The back-bearing is also cylindrical, carried in a solid bearing of bronze. To prevent end motion of the spindle, we secure to the spindle back of the back-bearing a carefully-made ring or collar of hardened steel. This collar is confined between a hardened steel thrust collar back of it and the back end of the back-bearing in front of it, and all these parts are enclosed in a tight cast iron tail block, which serves as an oil well to insure constant and perfect lubrication. The surfaces which confine the revolving collar front and back of it are so adjusted as to allow perfect freedom of rotary motion, but no perceptible end motion. The securing of the spindle endways is confined to the thickness of one collar only, and this is enclosed in so large a mass of cast iron as to insure a uniform temperature in all its parts; thus there is no liability to stick or jam, while the expansion of the spindle endways from this collar, if there is any expansion in access of the head, is allowed for in freedom of end motion in the front journal, which is a little longer than the front bearing in which it runs. In turning work between centres the thrust is taken against the thrust collar back of the fixed collar on the spindle, while in turning

No collars on front journal.

Back-bearing cylindrical.

Back-thrust.

Tail block.

Front journal longer than its bearings.

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chucked work the spindle is held in place endways by the confinement of the one fixed collar on the spindle between the fixed back-thrust and the back end of the back-bearing. With this arrangement of the spindle the change from one kind of turning to another requires no thought to be given to any adjustment of the spindle, to be ready for the changed condition of pressure, as is the case with lathes of ordinary construction. When the spindle of a lathe has collars at its front end, and is provided with an adjustable tail screw to take up the back-thrust, constant attention is required in the adjustment of these parts, and any neglect or error in the adjustment is soon shown in the worn condition of the collars, and it is seldom that any lathe, even in the hands of the most careful workman, long escapes this worn condition. A spindle held at one end by a collar and at the other end by a tail screw, set up to take up lost motion, may heat, and a very slight amount of expansion over that of the head itself will serve to produce an injurious amount of end binding, as is seen in the worn condition of such collars on lathes of the old style.

Defects of the collared spindle.

No tail screw.

Our form of back-thrust does away entirely with the tail screw, and in its place presents a large and very durable wearing surface. It also permits the extension of the spindle through the tail block to receive change wheels of any size for screw-cutting or for feed. The form of the live head is such as to hold the front-bearing rigid against the side strains, and the back-bearing against the strain of the spindle pressed endways.

The spindles of all lathes, up to and including 48 inches swing, are made of the best cast steel forgings in the manner above described, but in lathes of

greater swing we use cast iron spindles of much greater diameter as compared to the size of the lathe. In all lathes of all kinds the taper hole in the live spindle, in which the live centre is carried, is made true, after the head is finished, with the spindle revolving in its own bearings. The truth of this hole is as important as the truth of the outside of the spindle, as upon its absolute concentricity with the outside of the spindle depends the possibility of the centre being made to run true, no matter how it is replaced after it has been taken out. We make all centres of the same size lathes interchangeable, so that any centre will fit and run true in any lathe of the same size, provided the centre has been ground true to its own axis.

Cast iron spindles in large lathes.

Truth of hole for centres.

Centres interchangeable.

Spindles made as described above have been tested during many years of constant use, and have been found to show no perceptible wear; this is particularly the case with the peculiar back-thrust described. Possible adjustment to compensate for wear has been provided for, but the adjustment of these parts has been removed from the control of the workman using the lathe.

Durability of our spindles.

Our double-geared lathes, say those of 12, 16, and 20 inches swing, are provided with face plates to unscrew for convenience of changing from one size of face plate to another, and for the ready placing of chucking devices. All such lathes have their front journal made large enough to serve as a shoulder for the face plate to abut against, the nose of the spindle being the same diameter as the body of the spindle. This nose is not screwed over its entire length, but a portion of its length, next to the shoulder, is made truly cylindrical without any screw thread on that part. The face plate is made to fit the cylindrical part of the nose, and a

Face plates.

Face plates, how put in.

Nose of spindle.

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short and rather loosely fitted screwed portion serves to draw the face plate to place on the cylindrical part and hard up against the squared face of the journal, which acts as the squaring surface. Face plates arranged in this way may be taken off and replaced as often as need be without any danger of their being other than true when in place, unless the surfaces have been abused in their fitting parts.

Cone pulley. The cone pulley on the live head is turned true outside and inside to balance, and is provided with an inner sleeve presenting an extended surface on the spindle to insure proper lubrication when running loose on the spindle. The various speeds to be obtained from the cone in combination with the gearing have been so proportioned as to insure an exact ratio from the fastest to the slowest speed between each and every change.

TO DETERMINE THE LENGTH OF LATHE BEDS.

On page 116 we have already mentioned the manner of forming our lathe beds by the connection of the two sides of the bed by means of cross girts, which extend nearly to the top of the same. We have given, at the beginning of the article on lathes, and we now repeat a table, which gives the name or size of the lathe and its capacity of swing over the slide rest. This table also names the distance at which the cross girts are placed in the various sizes of lathes.

In this table the number of girts beyond the live head, in connection with the columns indicating the "Distance between centres" and the "Total length of the bed," show the shortest length of each size of lathe we make. Beds for lathes can of course be cast of any required length, but inasmuch as the distance

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Name of Lathe: that is, Diam. of Piece will swing clear of Bed.	Diam. will swing over Rest.	Distance from Centre to Centre of Girts.	No. of Girts beyond Live Head.	Distance between Centres.	Total Length of Bed.
12″	8⅝″	10″	4	2′ 4″	4′ 7¾″
16″	11¾″	13″	4	3′ 0″	5′ 10¼″
20″	15¼″	16¼″	4	3′ 8½″	7′ 4″
25″	19¼″	20¼″	4	4′ 6¾″	9′ 0⅛″
30″	23½″	24⅛″	4	5′ 5½″	10′ 8⅞″
36″	28⅝″	29″	4	6′ 7½″	12′ 10½″
42″	34½″	33¾″	4	8′ 6¾″	14′ 11¾″
48″	38½″	38½″	4	8′ 10″	17′ 0¾″
60″	49″	28″	6	9′ 1¼″	17′ 3⅛″
72″	57½″	31⅛″	8	10′ 0½″	19′ 9¾″

between the girts is made or determined by cores of definite length, we increase the length of our beds not by any increments of feet and inches, regardless of the length of our core boxes, but by the distance between the girts controlled by the core lengths. Thus, an inquiry is made for a lathe to swing 25 inches over the shear; this is called a 25-inch lathe, and it is required to turn work 10 feet long. Reference to the above table shows that the shortest length of our 25-inch lathe takes in 4 feet 1½ inch between centres, this is 5 feet 1½ inch too short; distance from centre to centre of the girts, as per table, is 20¼ inches, three additional girts 20¼ × 3 = 60¾ inches = 5 feet ¾ inch, added to 4 feet 1½ inch = 10 feet ¾ inch, which will meet the case very nearly; but should the lathe be required to turn work 10 feet 6 inches long, an additional girt will be needed, making 4 extra girts, and giving a lathe that will take 11 feet 8½ inches between the centres, which is more than is wanted, but is the nearest to the required size that our patterns will permit.

How to determine the length of lathe bed.

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rest, permitting its adjustment to any angle of cut. These lathes are heavily geared, and are well adapted to doing very heavy work, such as turning rolls for rolling-mills. The peculiar construction of the bed giving more room over the saddle than usual, and permitting a convenient arrangement of housings for holding rolls to be turned on their own bearings. The very great power of these lathes enables us to extend their usefulness, by dividing the bed near to the live head when a gap lathe is required. We thus are enabled to furnish say a 72-inch lathe capable of turning pieces 16 feet in diameter. When fitted as a gap lathe the bed is carried on cast iron shoes, and the lead screw of the lathe is made to actuate the parting of the bed to the required width of gap. A supplementary short shear carries a tool post and compound slide rest, such as we use on our driving wheel lathes, see page 150, the feed of which is obtained from a rock-shaft over-head by means of chains to the ratchet feed lever. The short shear above mentioned rests on extensions of two of the shoes carrying the bed, and on these extensions it can be placed in such position as to command the entire range of work possible on such a swing of lathe, say within the limit of the pit, which in the case of the 72-inch lathe is 36 inches wide.

Roll turning.

Gap lathe.

Slide rest for gap lathe.

COUNTER-SHAFTS AND SPEEDS.

Fast and loose pulley on the counter-shaft.

We make all the counter-shafts of our screw-cutting and turning lathes with one fast and two loose pulleys, so as to permit the use of open and crossed belts in screw-cutting, and the driving pulleys on the line shaft should be arranged to run the lathe backward at double the speed that it runs forward. To enable

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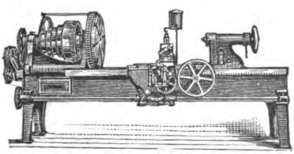
the proper driving pulleys to be prepared, we give in the following table the size of the pulleys on the counter-shaft, as well as the speed at which they should be made to run.

Table of the Speed of Counter-shaft of Lathes for Turning and Screw-Cutting.

Name of Lathe: that is, Diam. of Piece will swing clear of Bed.	Rev. Under Cut.	Rev. Running Back.	FAST AND LOOSE PULLEYS.			
			Diameter.	FACE.		
				Loose.	Fast.	Loose.
12″	200 Rev's.	320 Rev's.	8″	6″	6″	6″
16″	143 "	286 "	9″	6″	6″	6″
20″	112 "	224 "	10″	6″	6″	6″
25″	135 "	270 "	14″	7″	7″	7″
30″	110 "	220 "	16″	7″	7″	7″
36″	100 "	200 "	20″	4″	7″	4″
48″	90 "	180 "	26″	6″	12″	6″
60″	140 "	280 "	16″	7″	7″	7″
72″	122 "	244 "	20″	8″	8″	8″



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IMPROVED FRICTION FEED.

SINCE the first application of our friction feed discs to our tools we have improved their construction and extended their application to all tools to which a constantly acting feed is applicable, and where the feed is variable in amount.

Description of discs.

These feed discs consist of one driving disc, one driven disc, and two clamping discs. The driving and the driven discs are usually made of the same diameter, and these discs are each edged with a rim on each side of the central plate, such rim being about from one-quarter of an inch to three-eighths of an inch wide, and the surfaces of these edges are made to conform to the shape of the clamping discs, which pinch these edges on either side, and the clamping discs are made convex on their biting surfaces. The clamping discs are carried on a shaft that is provided with ball-joints fitting corresponding depressions in the centres of the discs, and there is provided a spring-pressure forcing the plates into contact with the driver and the driven discs, while at the same time there is no binding of the shaft which carries the clamping discs. This mechanism drives by friction, and the variation in feed is obtained by shifting the position of the clamping discs relatively to the stationary ones, so that the one or the other shall act nearer or farther from the centre of the clamping discs, producing the effect of wheels of stationary size being geared together by two wheels of the same diameter, or of different diameters, as the case may be. In using this system we gear

Clamping discs.

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down from the feed discs, and from a light pressure and considerable speed obtain any amount of feed power at a slow rate of operation. It will be found that these discs are in operation like a belt or any other means of frictional driving, and their durability depends upon the lightness of the work they are required to do. They should not be tightened up more severely than is required to do the work. Under these conditions their wear will not be appreciable, and the discs will furnish a convenient slip in case of accidental overwork, and so save the driven mechanism.

High speed of discs.

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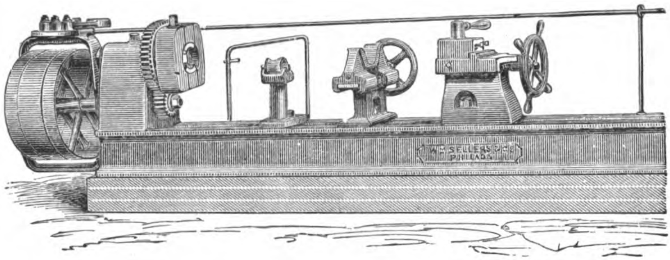
FIG. 47.



AXLE CENTERING AND SIZING MACHINE.

AS seen on page 143, we make a very convenient tool to be used in connection with axle lathes, to centre the rough axle, and after it has been turned to size in its journals and rough-turned in the "fit," to finish this part accurately, and to dress off the ends as well as to re-centre. This machine is provided with a powerful chuck lined with brass to clamp the axle by its outer collar. It is arranged with fast and slow motions on the driving gear. The axle rests in an adjustable V-guide at its end farthest away from the driving head; a squaring-up tool finishes the end of the axle, and at the same time re-centres it. The "fit" part of axle is brought to size by a hollow reamer provided with adjustable cutting blades. The pulleys on machine are 20 inches diameter, and require $2\frac{1}{2}$-inch belts. There should be two pulleys on line shaft, each one 5 inches face, and of such diameter as will cause the 20-inch pulleys to make 84 revolutions per minute for slow speed, and 264 for fastest speed.

Chuck.

Reamer.

Speed.

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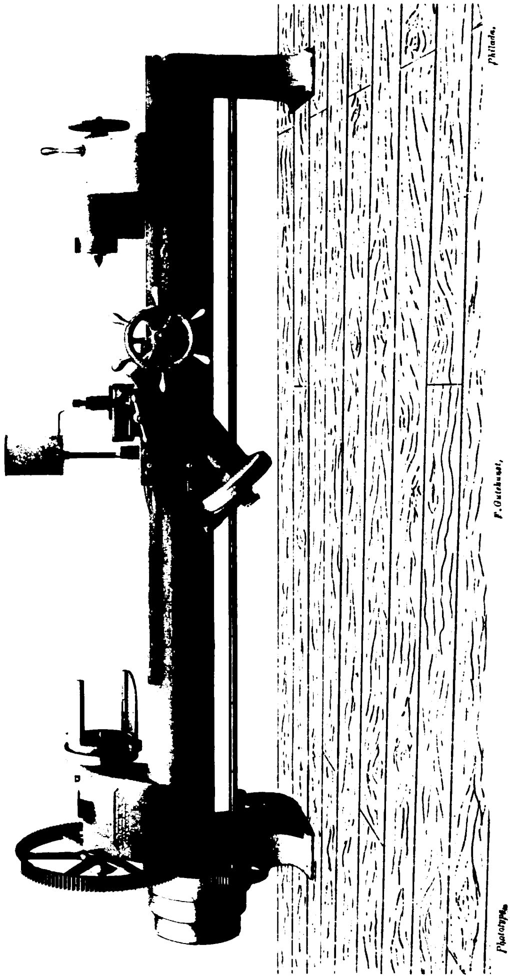
FIG. 48.



AXLE LATHE.

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AXLE LATHE.

For turning car wheel axles; strongly geared for taking heavy cut; Clement's driver on face plate; spiral pinion; a rack feed with quick hand traverse to bottom rest; improved adjustable tool holder; automatic feed motion, which can be started instantly; rate of feed, 12.5 to the inch; can to drop water on cutting tool. All working parts fended from chips and water. Iron cone pulleys, turned inside, so as to be perfectly balanced; over-head shaft, with ball and socket hangers, and two sets of fast and loose pulleys, viz., 24 inches diameter, 4 inches face, which should run 135 revolutions per minute, and 14 inches diameter, 4 inches face, which should run 225 revolutions per minute. A full set of wrought iron wrenches. Wrought iron work case hardened.

Former attachment for shaping centre of axles, extra.

THIS is one of our very important special tools, and in its design we had in view not only the greatest possible production, in work done in a given time, but also the greatest perfection possible in the work produced by not necessarily skilled workmen. In turning car axles there are two essential parts to be treated,—the "fit," that is, the part upon which the wheel is forced, and which requires accuracy of size; the journal, which demands less accuracy of diameter, but requires to be truly cylindrical and of smooth surface. It is customary to rough out the journal, taking from $\frac{3}{4}$ of an inch to $\frac{7}{8}$ of an inch depth of metal at one cut, with a feed of 12.5 to the inch. This very heavy cut makes a great strain on the axle, and if, in addition to this strain, the mode of rotating the axle is not of such a nature as to insure its not being strained sideways at the face plate or driving end of the axle, the work produced will be out of round.

"Fit."

Journal.

Strain of cut.

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In turning the greatest possible number of axles in any given time, it is of importance that all the motions required to be made by the workman shall be done quickly; hence convenience of adjustment and handling becomes an essential feature of the machine. The shears or bed is made in the form of a continuous cylinder of requisite strength, with flat surfaces added to the cylinder, for attachment of heads and bearing of slide rest. The live head or driving head is simple and powerful. The face plate is fitted with the so-called Clement's driver, which insures rotation of axle with no lateral strain on the centres. The back head has a very large, well-fitted spindle, with unusually large centre and a double clamping arrangement, which insures the spindle being held central and at the point nearest to the work. On top of this head is a grease box to hold the lubricant for the centre, at the handiest place for oiling the centre as the axle is being put into place. The slide rest, which is massive and strong, has an improved method of adjusting the point of the tool while under cut with care and precision. The feed is by a rack, operated upon by a spiral pinion after the manner of our driving motion in planing machines, with a clutch to stop and start, and, in addition, there is a powerful hand feed also. A water tank above the tool, drips water on the work being turned, and proper guards turn aside the water and chips from the wearing surfaces. With these conveniences it is possible for one man to produce from 11 to 12 Master Car Builders' Standard Axles in 10 hours, while of the old style of car axles, smaller in the journal and wheel-fit, from 18 to 20 axles have been turned by one man in 10 hours.

Convenience. Shape of shears. Face plate. Back head. Slide rest. Feed.

Former attachment.

We also adapt a former attachment to these lathes

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when required, to turn the central part of steel axles to shape, or for other work where shapes or tapers are desired.

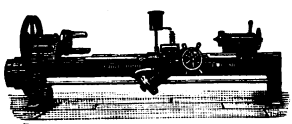
In operating these lathes there are two speeds on the counter-shaft, the slow one for the roughing cut, and the fast one for the finishing cut.

The fast and loose pulley, 24 inches diameter, 4 inches face, should make 135 revolutions per minute, and those 14 inches diameter, 4 inches face, should make 230 revolutions per minute. These speeds may be obtained by driving from the same size pulley on the line. **Speeds.**

The above applies to iron axles.

In turning steel axles the speed of cut must be reduced; while 18 feet per minute-speed of cut in roughing will do for iron axles; hard steel axles will require the speed to be reduced to 8 feet per minute; soft steel axles can be turned at the rate of 17 feet per minute. By speed of cut we mean the rate of speed at which circumference of work being turned, passes the tool while cutting.

We advise the use of a separate tool for sizing the wheel-fit, for dressing up the ends of axles, and for re-centering. See page 138. With this machine 80 to 100 axles can be re-centered and reduced to size at wheel-fit per day. Actual time required for each axle being about 6 minutes. The machine will rough-centre axles in about the same time. This tool saves time in the axle turning, as less care is bestowed on the wheel-fit. **Sizing tool for wheel-fit. See page 138.**



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20-INCH CHASING LATHE.

(*For Report of Judges, see page* xiv.)

Arranged especially for brass work, live head back geared; hammered steel spindle running in special bronze bearings; improved back thrust to spindle; iron cone pulleys turned inside so as to be perfectly balanced. Spindle for holding the chasing hobs so arranged as to accommodate two different pitches at the same time. Also to cut with single-pointed tool either single, double, triple, or quadruple threads. Slide rest for patent chasing arrangement carried by bar at back of lathe; counter-weight to chasing bar, pressing either to or from the face plate; poppet head with square spindle and detachable screw for quick motion, can be adjusted to any taper when used to carry turning tools, and is provided with slide rest movement; patent holdfast for poppet head; hand tool rest with convenient holdfast; steady rest; over-head shaft fitted with ball and socket hangers, and one fast and two loose pulleys, all 16 inches diameter, 5 inches face, which should run 168 revolutions per minute, with open and cross belts to run the lathe at uniform speed either way.

THIS is a special tool, made in the first place for our own use in our Injector shop, and there demonstrated to be a better tool for general brass work than any yet made. It cuts screws by means of a hob of the requisite pitch on the spindle back of the lathe spindle. The back or poppet head has all the movements of an ordinary slide rest, and is made to carry either boring tools or turning tools, and permits of the most economical working of chucked work. Lathes of this kind are not used for turning work between centres, but for operating upon work held and carried by the face plate; thus, upon the bodies of all kinds of globe valves and brass work generally.

Hob for cutting screws.

Turning chucked work.

To use it to advantage on any special work, a system of chuck plates adapted to hold the work (if a universal chuck is not applicable) should be arranged by the purchaser to permit his placing the pieces to be turned in the readiest way upon the face plate.

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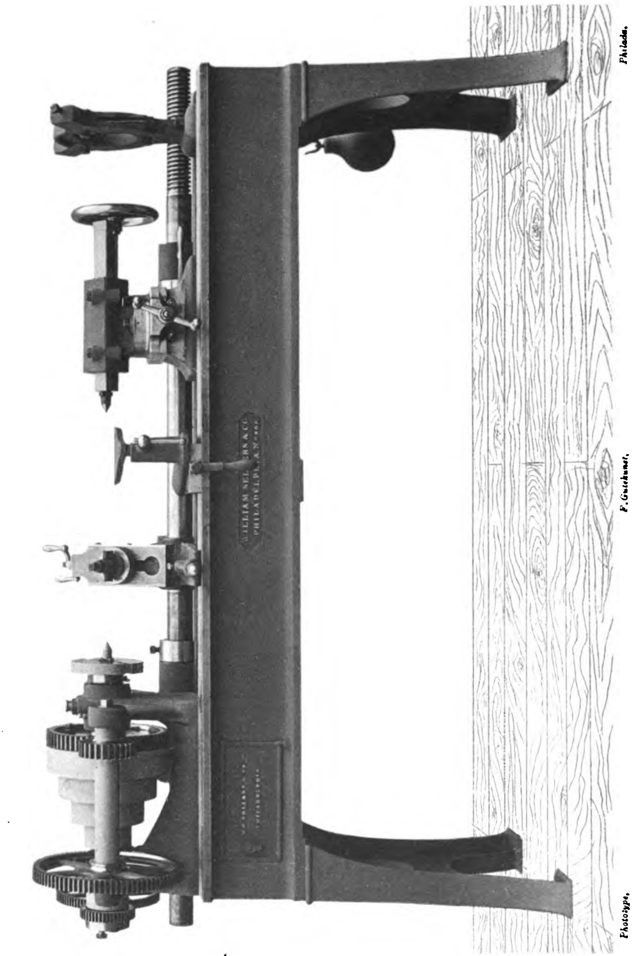
FIG. 49.



DOUBLE GEARED CHASING LATHE, 20 INCHES SWING.

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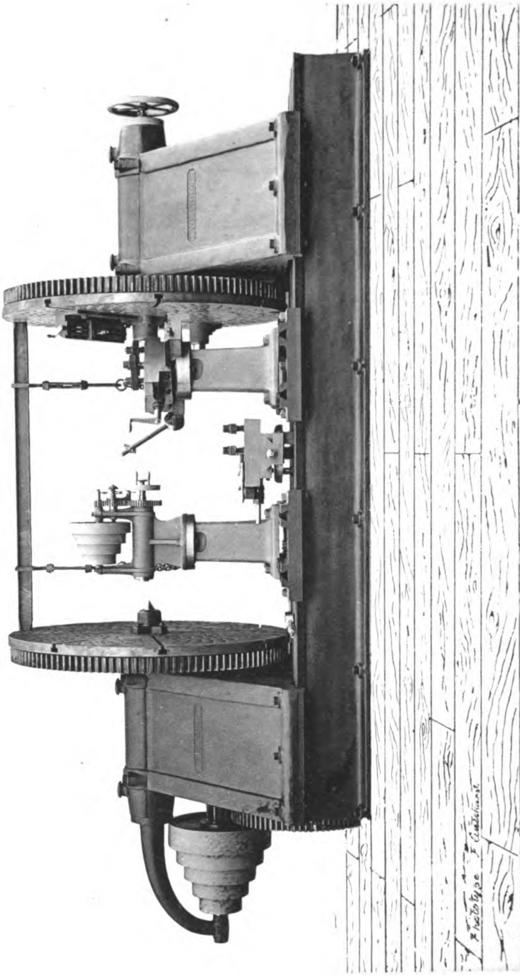
FIG. 50.



PATENT WHEEL TURNING LATHE, 78-INCH SWING.

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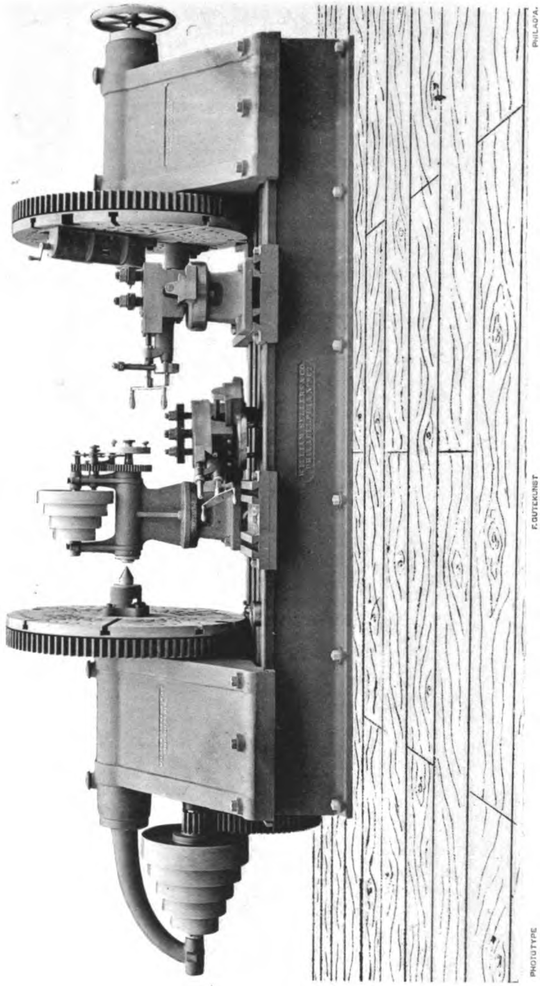
FIG. 50A.



PATENT WHEEL TURNING LATHE, 54-INCH SWING.

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WHEEL TURNING LATHE.

(*For Report of Judges, see page* xv.)

Arranged for boring or turning both wheels at once, with two geared head stocks, two large face plates, with external and internal wheels driven independently, so that the workman may be chucking on one and turning on the other at the same time; with two compound slide rests, self-acting feeds in all directions, over-head shaft, ball and socket hangers, and iron cone pulleys turned inside so as to be perfectly balanced, and a full set of wrought iron wrenches. Wrought iron work case hardened.

Same tool with one geared head stock and one slide rest; in other respects as above.

Same tool with one geared head stock and two slide rests; in other respects as above.

Sizes of Machines.

Size of Lathe.	Diameter of Face Plate.	From Centre to Top of the Shear.	Distance between Face Plates.	Total Length of Shear.	Diameter of Pulleys on Counter-shaft.	Speed of Counter-shaft.
90″	7′ 6½″	3′ 9 7/16″	8′ 1¼″	16′ 5″	24″ × 7″	50 Rev's.
78″	6′ 6½″	3′ 3½″	8′ 6″	15′ 7″	24″ × 7″	50 "
66″	5′ 6½″	2′ 9½″	8′ 6″	14′ 10½″	24″ × 7″	50 "
54″	4′ 6½″	2′ 3½″	7′ 3¼″	13′ 6″	20″ × 5″	50 "

Wheel quartering and hub facing attachment, extra for each size.

Splining attachment, extra.

Patent hoisting attachment for lifting wheels on axle into lathe, extra.

THIS is believed to be the most efficient tool for turning driving wheels for locomotives that has been built. Its principle admits of unusual stability. The pressure of cut always falls within the bed surface, and its exceeding simplicity recommends it for the work it is designed to do. The feed is obtained from a rock shaft placed over-head, from arms on which chains are carried to ratchet feeds on the compound slide rests. This enables the feeds to

Pressure of cut within surface of bed.

Feed.

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be operated to equal advantage in all directions by power, and to be entirely under the control of the workman. We recommend the machine with two driven face plates and two slide rests, but we make it when required, as is shown in specification, with one geared head stock only. The difference of cost, in our estimation, does not warrant the dispensing with the two face plates, the work being done so much more rapidly when both wheels are driven at once. By its use wheels may be taken from under an engine and the tires re-turned with but a few hours' detention of the engine in the shop.

Two face plates.

The machines offered cover the entire range of sizes of wheel used in modern railroad practice. Our 54-inch lathe has been especially designed to meet the requirements of the narrow gauges, and its slide rests are so made as to permit the entrance of at least one of them between the driving wheels of the narrowest gauge, close to the axle, for the purpose of re-turning the journals of the axles when they need such attention. Is admirably adapted for use on paper wheels.

Narrow gauge lathe.

WHEEL QUARTERING AND HUB FACING ATTACHMENT.

For wheel quartering we furnish a portable horizontal boring machine, which takes the place of one of the slide rests upon its post, and when so placed its spindle is on a level with the centres of the lathe. This boring machine is provided with the most improved self-acting feed motion, either forward or back, and quick return by hand. When lathes are ordered with the quartering attachment, the face plate furthest away from the driving cone has four of its T slots planed truly at right angles, and these slots, one pair vertical and the other horizontal, are made to serve

Slots in face plate.

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the purpose of quartering the crank holes. The face plate is clamped to place by means of a block, which fastens the bottom end of the vertical slot to the bed plate or shear. The horizontal slot is provided with adjustable plugs, which, set to one or the other side of the centre, serve to fix the position of the crank hole to be bored either for right or left hand crank lead. The boring is done from between the wheels towards the live head face plate, the finishing cut being made from outside of wheel. A slide rest bolted to the horizontal slot in the first-named face plate serves to turn up the whole of the outside of the wheel crank, boss, and centre, the slide rest being stationary and the wheels being driven by the face plate on the live head.

Quarters right or left hand crank lead.

SPLINING ATTACHMENT.

For this purpose the splining tool is carried by one of the slide rests, the bottom saddle carrying the post and slide rest is moved back and forth by means of a screw, cut on the main driving shaft of the lathe.

PATENT HOISTING ATTACHMENT.

We provide in both face plates circular pockets near to the rim, which pockets are for the purpose of sustaining the ends of a small I beam of a length adapted to the gauge of the road. On this I beam are sling chains and screw swivels to attach to the axle between the wheels. By means of this very simple and not cumbersome device the wheels on their axle are swung up to the centre by the rotation of the two face plates through say one-quarter of a revolution. Wheels rolled up to the back of the lathe are thus lifted in with great ease.

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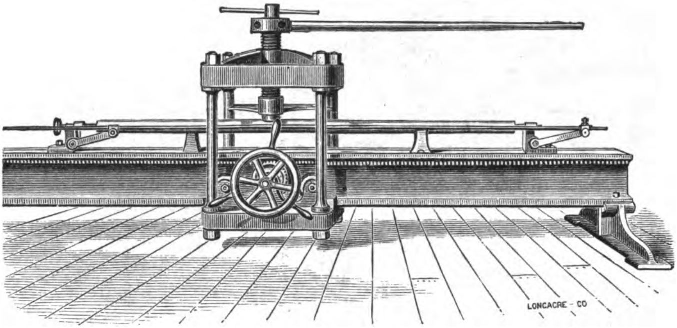
FIG. 51.



STRAIGHTENING MACHINE.

With bed 20 feet long, bending screw traveling the whole length, and the work to be straightened stationary, with centres for shafting to elevate and depress: with a full set of bending blocks; the whole capable of straightening a shaft 6 inches in diameter when cold. Wrought iron work case hardened.

THIS is an indispensable machine in any establishment where shafts are turned. The work having been centred, can in this machine be straightened quickly and thus made ready for the lathes.

In turning long shafts, even when the utmost care is observed, the finished work is almost invariably found to be crooked. This may be caused by the burnishing action of the cutting tool, acting on harder or softer parts of the metal, or by the removal of the scale from the rough iron. Finished shafts can be readily made straight in this machine; it is exceedingly useful, also, in bending or curving iron, other than round; as, for instance, curving T-rails for railroad purposes.

Use in bending rails.

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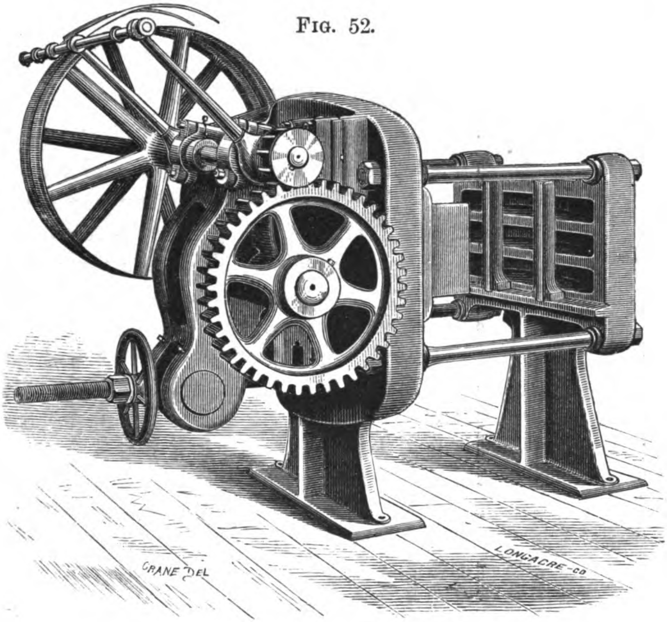
FIG. 52.



POWER STRAIGHTENING MACHINES FOR BEAMS.

Bending plunger working horizontally; driven by a powerful crank with an uniform stroke, but the position of the stroke adjustable; will take in 15-inch beams; can be used for straightening bars, or shapes. Fast and loose pulleys on machine, 36 inches diameter and 7 inches face; speed, 150 revolutions per minute.

BEAMS and other shape irons used on bridge work are most generally handled on trussels during their assemblage into the parts of structure. This machine operates upon the beam as it lies on the trussels, and at a convenient height for sighting.

We make the same kind of machine to be operated by hand when desired.

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HOISTING MACHINES.

WE have during many years made and erected hoisting machines for warehouse purposes. These are arranged to operate with a worm and worm wheel, with driving pulleys on the worm shaft to actuate the machine. The worm wheel and worm are inclosed in an oil-tight box, so that the worm is at all times encased in oil.

Worm and wheel.

Belt shifter.

The belt shift motion is similar to that used on our planers, and is provided with an adjustable automatic stop motion. This device causes the machine to stop at top and at bottom of the hoistway entirely independent of the motion of the cage, or platform. That is, when enough rope has been carried on to the drum to have hoisted the platform to top of hoist, the machine stops. When enough rope has been unwound to have lowered the platform to the bottom of the hoistway, the machine also stops. This avoids all the accidents incident to unwinding the wire-rope, and afterwards winding up in the wrong direction, when the platform has caught on some impediment in descending, in machines arranged to be stopped by the platform. We estimate for hoisting machines, cages, etc., put up with any of the most improved safety catches, or we sell the machines for millwrights to put in place with such form of cage or platform and safety-catches as they may prefer. We also arrange the same machine as a pavement hoist. We have three sizes :—500 pounds, 2000 pounds, and 4000 pounds. The usual speed of hoist is from 32 to 60 feet per minute.

Automatic stops.

Safety catches.

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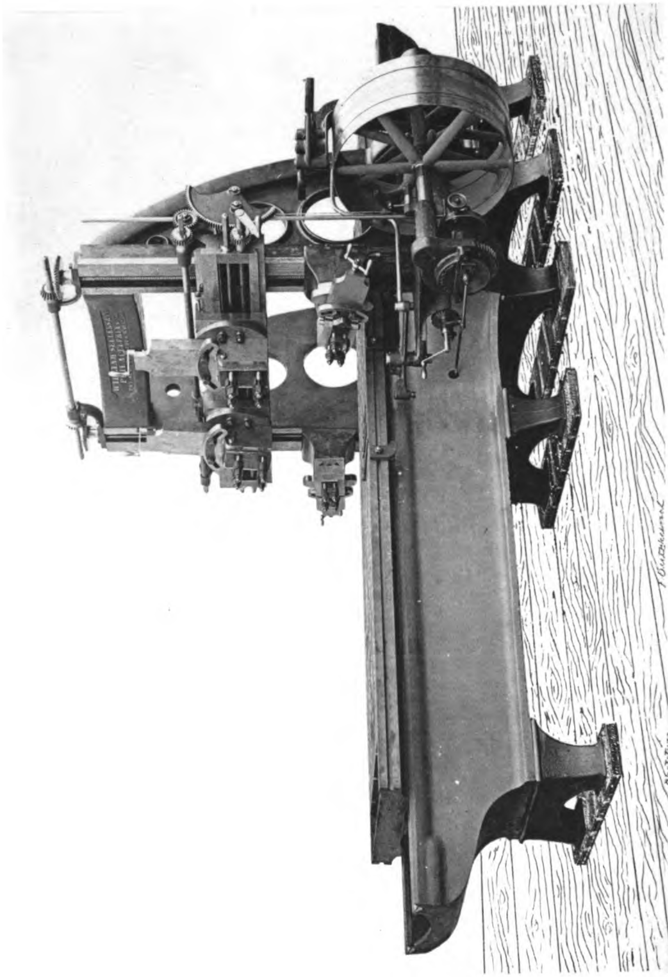
FIG. 53.



Phototype. F. Gutekunst. Philadelphia.

36-INCH x 36-INCH PLANING MACHINE.

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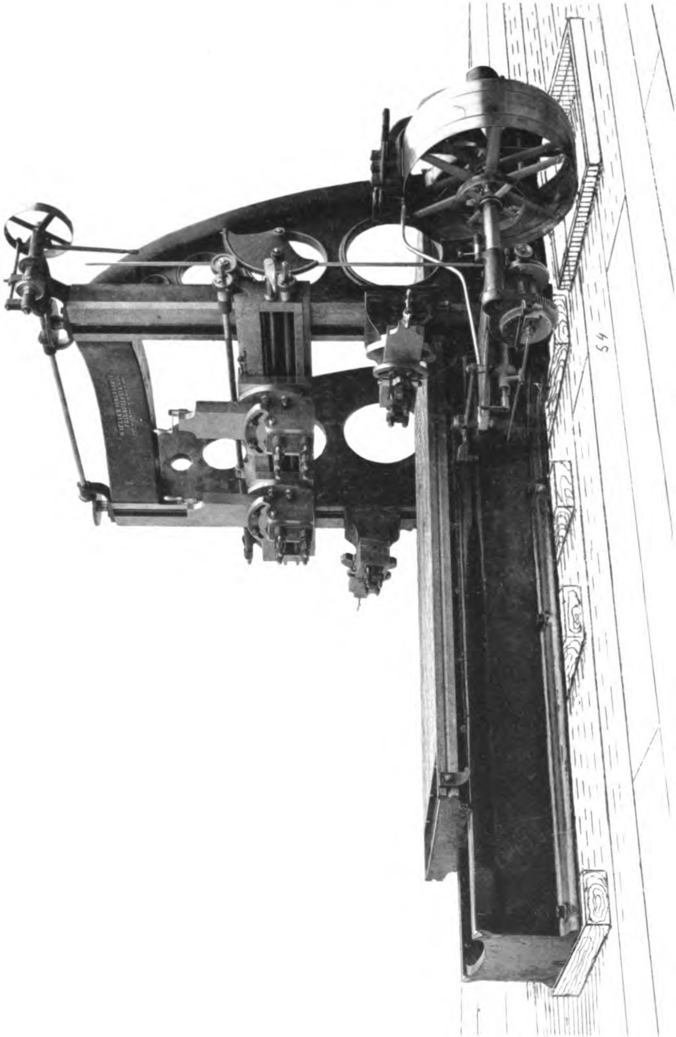
Fig. 54.



60-INCH x 60-INCH PLANING MACHINE.

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SELF-ACTING PLANING MACHINE.

(*For Report of Judges, see page* xiii.)

For horizontal, vertical, and angular planing of any required length, with spiral gear driving motion; positive geared feeds, self-acting in all directions, with tool lifter operating at all angles, and improved belt shifter.

This machine stands parallel with the over-head driving shaft, thus economizing room in the shop; the bed and table are fitted to uniform gauges, so that the table will work with either end toward the uprights, or on any bed of the same size machine, thus insuring the correctness of the ways.

The planer in its simplest form has only one saddle on the cross head, and the price of such a tool is fixed at the lengths given in the following table:

Name of Planer.	Will plane— In Width.	Will plane— In Height.	Shortest Length of Table.
20 inches.	20 inches.	20 inches.	3 feet.
25 "	25 "	25 "	4 "
30 "	30 "	30 "	5 "
36 "	36 "	36 "	5 "
42 "	42 "	42 "	6 "
48 "	48 "	48 "	6 "
54 "	54 "	54 "	7 "
60 "	60 "	60 "	8 "
72 "	72 "	72 "	9 "
84 "	84 "	84 "	10 "
120 "	120 "	120 "	14 "

Planers can be made of any required length, the price being fixed on each extra foot of *table* beyond the shortest length given in the table.

All planers of 30 inches capacity and over can be fitted with extra saddle on the cross head. With the extra saddle we provide a cross head of extra length, to permit one saddle being run far enough over to allow the remaining one to operate over the whole width of planer. When extra saddle is ordered an independent screw feed is furnished, to permit each saddle to be worked separately from the other. The vertical slide movements of both saddles being obtained from one feed rod.

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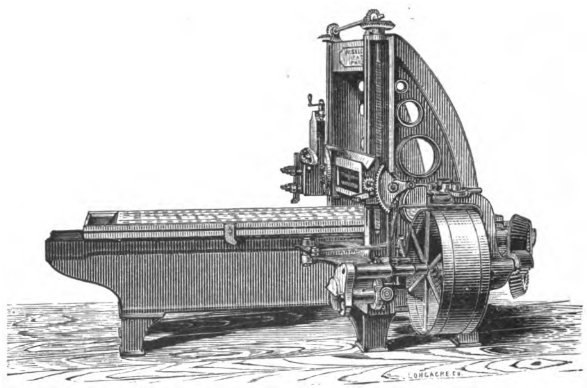
For all planers of 36 inches capacity and over we can furnish vertical slides on the uprights, or one plane upright with vertical slide on the remaining one. These vertical slides carry their tools at the same distance from the face of the uprights as do the saddles on the cross head. All the cutting tools begin and end their cut in line with each other.

All planers of 48 inches capacity and over have power hoist to the cross head. The over-head shaft is fitted with ball and socket hangers, and the pulleys are perfectly balanced; a full set of wrought iron wrenches accompanies each machine, and wrought iron work is case hardened.

N.B.—Inquiry for price of planers should state width and length required to plane. If extra saddle on the cross head is needed or vertical slides on the upright, mention should be made of each requirement, and if vertical slides are not needed on both the uprights, we will place the one wanted on the pulley side of the machine.

FIG. 55.



PATENT SELF-ACTING PLANING MACHINE.

THIS machine, differing in so many particulars from planers as heretofore made, has proved itself so durable and efficient as to have attracted the attention of all the principal users of such machines. The editor of the *Practical Mechanics' Journal*, London, in commenting on the machine

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tools exhibited in the Paris Exposition of 1867, begins an article on "American Planing Machinery":

"Amidst the countless machine tools exhibited last year in Paris by every foremost maker in every prominent nation in the world, there were none so remarkable for the breezy freshness and originality in the conception and carrying out the contrivance of various parts, by which the combined action of each machine tool as a whole was obtained, as those produced in the United States divisions by Messrs. William Sellers & Co., of Philadelphia." We here reprint the substance of the description of these machines, as given in that journal, adding such remarks of our own as may assist in a full appreciation of the merits claimed for this tool:

"Most conspicuous and important among the various novel features of this machine is the manner of giving motion to the table; this is furnished with a rack, but instead of being operated by the ordinary spur gearing, it receives motion through a peculiar form of spiral pinion upon a driving shaft which crosses the bed diagonally, and passes out in the rear of the upright, on the side where the workman stands. This shaft is driven from the pulley shaft by means of a bevel wheel and pinion. The position of the pulley shaft places the driving belts within convenient reach of the operator; and its axis being parallel with the line of motion of the table, these machines may be placed parallel to lathes, and thus economize space and permit a better arrangement of workshops. By this simple driving arrangement a very smooth and uniform motion is imparted to the table; the pinion has four teeth, and is, in fact, a short piece of a coarse screw, the position of the teeth upon the same being

See Figs. 56, and 57, Pages 162 and 164.

Driving the planer.

Machine stand parallel with lathes.

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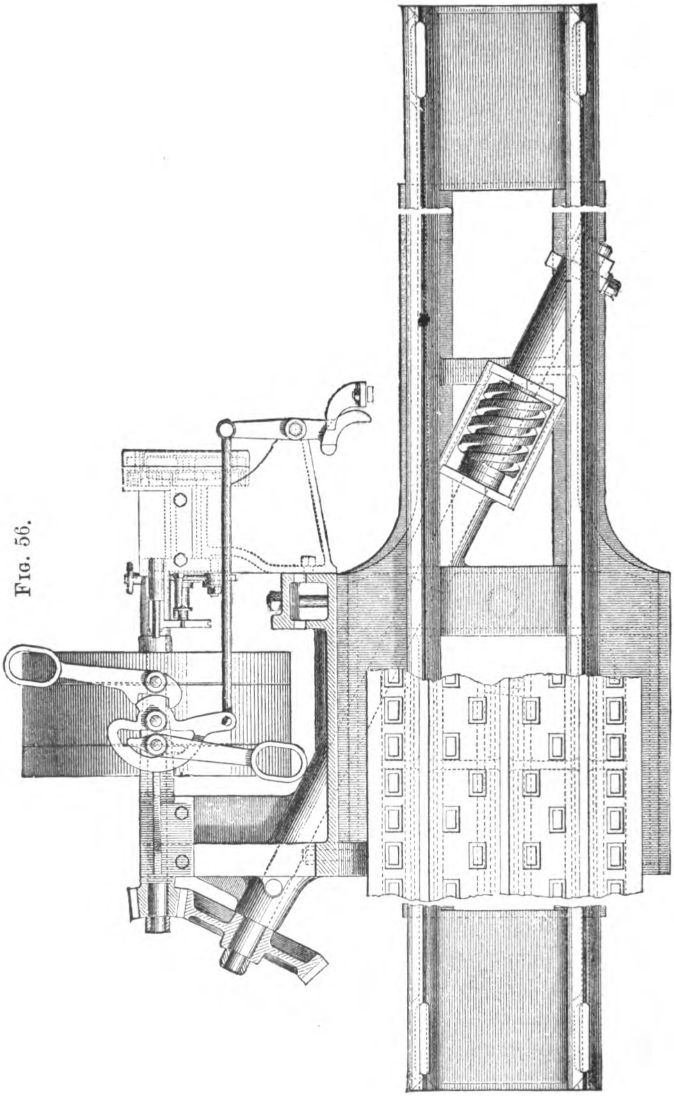

Fig. 56.

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as the threads of a screw of a steep pitch, and of a like number of threads to that of the teeth in the pinion. This pinion being placed upon the diagonal driving shaft, its action differs from that of an ordinary spur wheel, as it also does from that of a worm; that is to say, if the driving shaft were at right angles to the rack, the pinion would be the ordinary spur; but if it were inclined to the rack, say 5°, the teeth of the pinion would require to be slightly curved, and would commence driving at one side of the rack, shifting gradually to the other as it revolved. The same process takes place at any other angle, the sliding cross motion being more rapid the greater the angle from the perpendicular, until it reaches 90°, when it becomes a worm, and the teeth of the rack would then require to correspond with the angle of the thread. With the present arrangement, however, the teeth of the rack must be straight, but may be placed at any convenient angle to the line of the rack. Although the teeth of the latter are straight, and those of the pinion curved, the surface of contact and wear upon the rack is not limited to a small central portion of its teeth, but uniformly distributed over the whole width of the rack.

Action of the spiral pinion.

Teeth of rack straight.

"In the arrangement we are describing, the teeth of the rack are placed at an angle of 5° to its line of motion, to counterbalance any tendency the pinion might have to move the table sideways. The driving shaft revolves in bearings at both ends of the spiral pinion; these bearings are cast in the bed and connected by a trough surrounding the pinion, which trough is covered by caps under the rack, thus preventing chips and dust from reaching the pinion; the oil placed upon these bearings can escape only into

See Fig. 56, Page 162.

Pinion protected from dirt.

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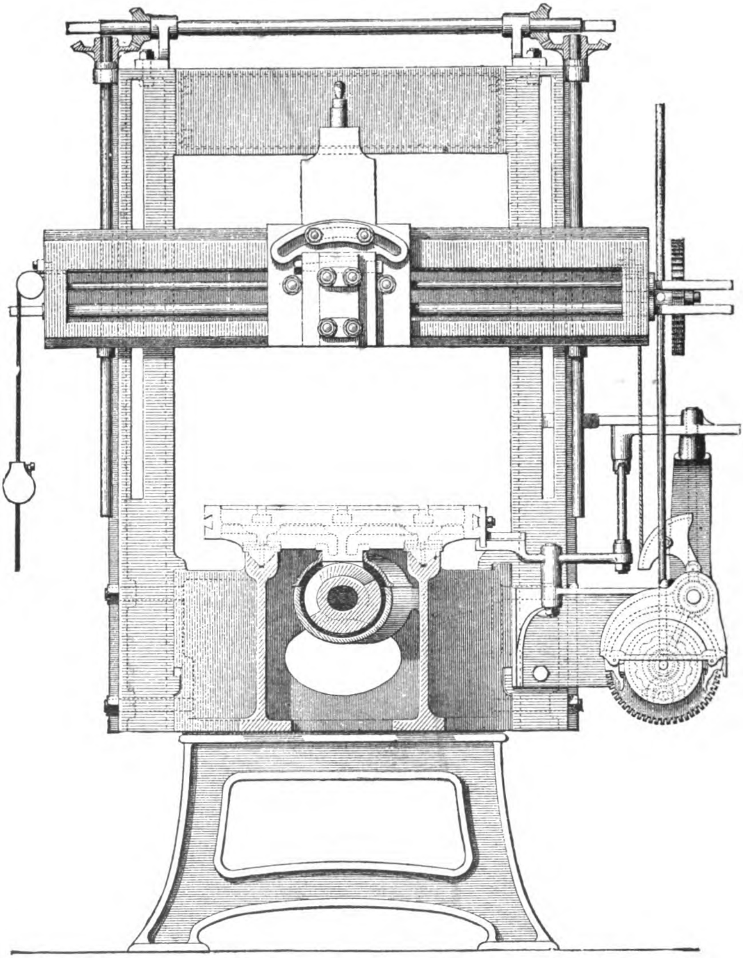
FIG. 57.



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this trough, and furnishes sufficient lubricating material for the pinion and rack.

Oiling the pinion. "It is a mistake to suppose this pinion must run in oil; in fact, such a condition of affairs would be highly injurious, as the oil would be thrown off by the revolution of the pinion, and would become a serious nuisance. **Thrust of pinion shaft.** The thrust upon the driving shaft from the motion of the table under cut is received against a step-bearing in front, and the lesser thrust during the quick return motion is received against hardened collars at the other side of the spiral pinion.

Bracing in bed. "It will be noted that the sides of the bed directly between the uprights are very firmly braced by a box-shaped connection, the diagonal driving shaft not interfering with it, thus strengthening the most vital part of the machine, which is not the case in most of the ordinary forms of planers; the same space being in some rack planers occupied by the gearing, while in the screw planer the height of the cross braces must be much diminished to give room for the screw and nut.

Position of belts as regards workman. "The disposition of the driving shaft and gearing in this machine may also be looked upon as an improvement over the frequently adopted plan of placing the driving gear and pulleys in front of the uprights, on the side of the machine opposite to the attendant; **See Fig. 56, Page 162.** in which position these parts and the belts are apt to interfere with the planing of pieces overhanging on that side of the table, and are out of the reach of the operator. The transmission of motion to the table from a high speeded belt is accomplished by **Bevel wheel.** a single pair of bevels, the largest one of which may be easily made of such diameter, relative to the pinion, as to give the required reduction of speed and

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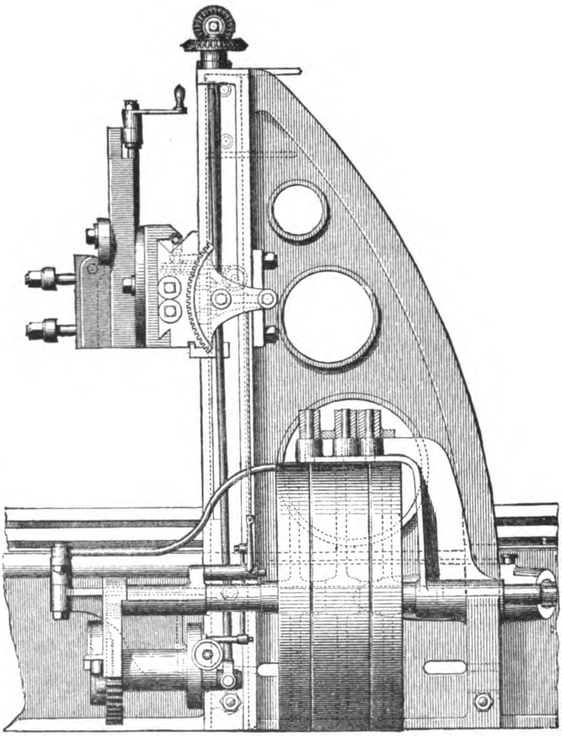
FIG. 58.



transmission of power without the intervention of other gearing. This arrangement has evident advantages over the ordinary screw planer, in which the gearing at the end of the screw is limited in size by the table projecting over the ends of the bed. The

Belt shifter.

device for shifting the belts in the Sellers' planer is

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another peculiarity worthy of notice; it consists of a curiously shaped lever, vibrating horizontally upon a fulcrum pin placed between the fulcrums of the two belt shifters; the whole being supported upon an upward extension from the cap of the rear bearing of the pulley shaft. The middle arm is provided on opposite sides with an internal and external projection or tooth, these teeth meshing with corresponding notches and projections on the respective shifters; the teeth upon the middle lever are relatively so disposed that the motion of one shifter is effected and completed before that of the other is commenced, which arrangement combines, with the least possible lateral motion of the belt in shifting, the important advantage of entirely removing the one belt from the driving pulley before the other commences to take hold to reverse its motion. The shifting is thus effected with very little power, and the shrieking and undue straining of belts avoided. See Figs. 56, 57, Pages 162, 164.

Length and adjustment of stroke.

"The variation of stroke of the table is obtained by means of the usual adjustable stops on the side of the table, which stops actuate the above-described shifting device by means of a double-armed lever and link connection. This lever and link are in the most convenient position for changing the position of the belts independent of the stops, so that the workman can with great facility control and reverse the motion of the table by hand in setting the tool or in planing over intervening irregular lengths; he can also set both belts on the loose pulleys, and thus at any point arrest the motion of the table without stopping the counter-shaft.

Feed.

"Several novel features are also introduced in the feed motion for the cutting tool, and in the devices

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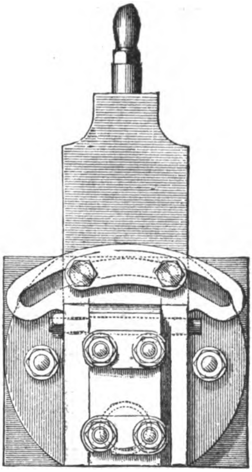

Fig. 59.

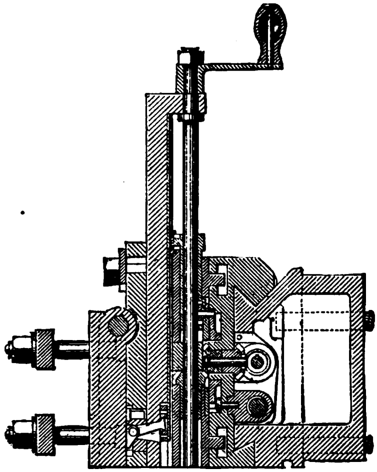

Fig. 60.

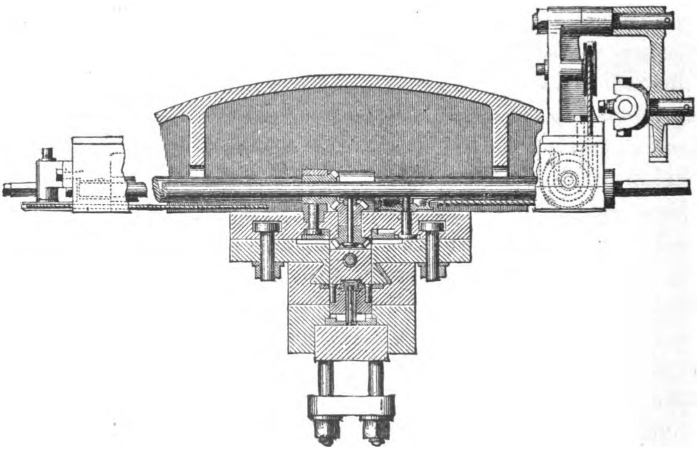

Fig. 61.

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for elevating the cutting tool during the return stroke of the table. The usual screw and central feed shaft are provided in the cross head for transmitting either a horizontal or vertical feed motion to the planing tool in either direction; they receive a variable amount of motion for any required amount of feed through a ratchet wheel, fitted interchangeably to their squared end projections at the front end of the cross head, where the ratchet wheel is actuated by a toothed segment, which receives at each end of the stroke the required alternate movements in opposite directions from a crank disc below by means of a light vertical feed rod. The crank pin on the feed disc below is so arranged that its throw and amount of feed can be conveniently varied and adjusted during the cutting stroke of the table, while the machine is in motion.

FIG. 62.

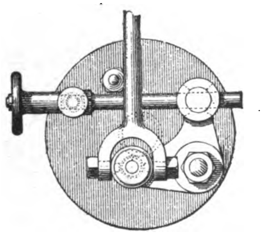
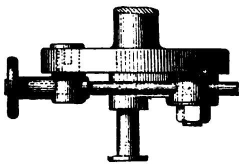


FIG. 63.



By means of an ingeniously contrived double pawl and ratchet wheel, deriving motion from a pinion on the front end of the pulley shaft, the crank plate is at each reversion of the stroke alternately moved a half revolution, and disengaged in either direction; friction is only employed to throw the pawl into gear at each change of motion, whereupon a positive motion of the crank disc is kept up by the ratchet wheel until the pawl is disengaged from the teeth of the ratchet wheel See Figs. 57, 64, and 65, Pages 166, 170.

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Fig. 64.

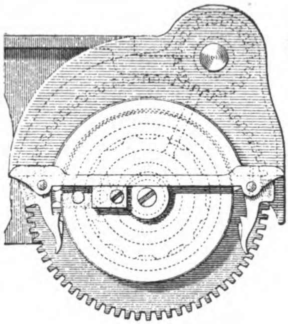
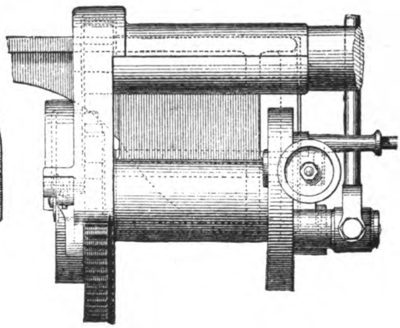


Fig. 65.



Comparison with other methods.

by a positive stop. In nearly all planing machines the feeding motion of the cutting tool is obtained from the belt-shifter, which is actuated by stops upon the table, as described; such an arrangement entails an undue amount of work upon these stops, whilst the variations of feed obtainable in this way are quite limited; besides which, under many circumstances, it will be found necessary to make the feed under the cut, as the feed motion will be always actuated at the end of the stroke before the motion of the table is reversed, whilst in a feed motion actuated from the gearing the motion will always be produced at the beginning of the stroke, and the amount of feed to be obtained in this way is practically unlimited. In nearly all modern planing machines the cutting tool is hung in what is called an apron, so adjusted as to allow the tool to swing loose on the back stroke of the planer table, but to be held rigidly when cutting. In large planers when the weight of the tool is great, and in all fine planing, this liberation of the tool is not sufficient of itself, but va-

Feed.

See Figs. 59, 60, and 61, Page 168.

Apron.

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rious arrangements have been added, whereby the tool point can be actually lifted clear of the work on the back stroke, and dropped into place ready for the cut, after the article to be planed has passed under it; but perhaps none of these contrivances are so completely applicable as this one for lifting the tool in every position of the slide rest, and to do so from within the cross head, without interfering with any of the machinery for working the feeds, which occupy the centre, about which the adjustable part of the saddle rotates."

Lifting tool point on back motion.

To this may be added that recent experiments seem to demonstrate that the great durability of the spiral pinions and rack used in driving these machines, is due to the fact that the action of the teeth is more a rolling action than a rubbing or sliding one. The ways or V's in the bed are provided with oil dishes at each end to retain the oil used in lubricating them, and the planer tables have self-operating oil scrapers, which, during the motion of the table, distribute oil uniformly over the surface of the ways. Planers up to 36 inches capacity, inclusive, are arranged with legs or feet to rest on the floor, but all larger sizes are intended to be placed on foundations; and it is recommended that they be set upon stone sills crossing the bed at each pair of foundation bolt holes, so as to prop up the machine to the required height, and to permit the ready removal of the chips that may fall inside of the bed.

Durability.

Oil dishes.

See Fig. 56, Page 162.

Legs.

See Fig. 57, Page 164.

We name in our schedule of prices the shortest length it is possible to make these machines, and then give the price per foot for extension of table; and in the tabular lengths given the distance is measured from the centre of the cross dishes at each end of table, and not of the actual length of plane surface

Length of table.

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of table. We do this because, be the length of table what it may, if the work bolted to the table is stiff enough to overhang these dishes, it can be effectively operated on by the machine.

Erecting the machine.

In placing these machines, it is of the utmost importance that they be carefully lined up when being put in place. On the larger sizes of planers we arrange vertical slide rests, attached to the uprights and operated by independent feeds, to enable work to be planed on the sides or edges at the same time that the surface is being planed. These are either adapted to one upright or both, as may be required; and, in case of one only being used, we place it on the working side of the machine,—*i.e.*, on the upright next to the driving pulleys. These vertical slide rests are capable of being lowered below the surface of the table, so as to be entirely out of the way when not required. On locomotive work especially, these vertical slide rests are of great use. Two saddles are sometimes required on the cross head of planers of 30 inches capacity and over, to enable two cuts to be taken at the same time on the surface of work; they are so used in locomotive shops for planing frames and guide bars. When two saddles are adapted to any machine they are provided with a convenient method of moving them sideways, by hand, independent of the regular feed motions. Some care must be taken in placing the counter-shaft so as to insure the belts passing through the belt forks in the best position; to facilitate this setting, we send with each machine the following table:

Vertical slide rests on uprights.

Two saddles on cross head.

Placing the counter-shaft.

See Fig. 66, Page 174.

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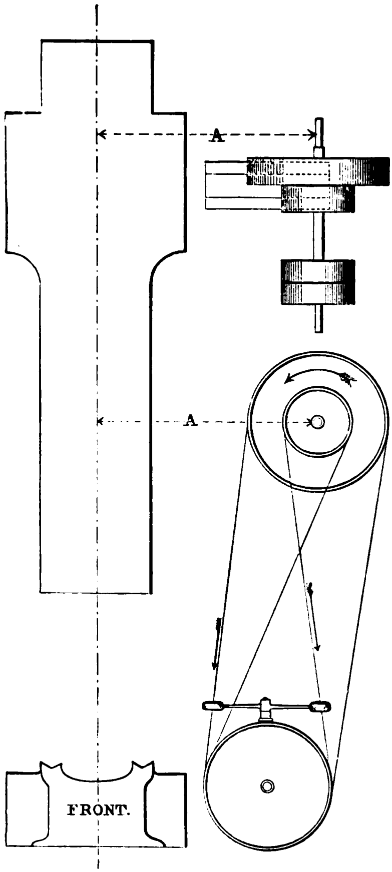
FIG. 66.



PLAN AND ELEVATION—SHOWING BED OF MACHINE AND POSITION OF COUNTER-SHAFT.

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DIRECTIONS FOR LOCATING THE COUNTER-SHAFTS OF WM. SELLERS & CO.'S PLANING MACHINES.

SMALL pulley on counter-shaft drives planer FORWARD, with a CROSS BELT.

LARGE pulley drives BACKWARD, with an OPEN BELT.

The counter-shaft must be set for each machine as per following table, to allow the belt shifters to throw the belts properly.

In no case can the centre of counter-shaft be vertically over the centre of pulley shaft on machine.

NAME OF PLANER.	COUNTERSHAFT.		Distance A from centre of Bed of Machine to centre of Countershaft.	Minimum to which distance A may be reduced to suit low ceilings.
	Speed.	Diameter and Belt of Fast and Loose Pulleys.		
20″	300 Rev's.	8″ Diam. 4″ Face.	27½″	27½″
25″	256 "	12″ " 4″ "	35″	35″
30″	236 "	14″ " 4″ "	41½″	35″
36″	220 "	16″ " 4″ "	47⅞″	43″
42″	209 "	18″ " 6″ "	52⅞″	49½″
48″	228 "	18″ " 7″ "	58″	54¾″
54″	228 "	18″ " 7″ "	61″	57″
60″	207 "	20″ " 7″ "	69¾″	63¾″
72″	198 "	22″ " 7″ "	78½″	74″
84″	190 "	24″ " 7″ "	90″	85″
120″	170 "	27″ " 7½″ "	117⅜″	113″

The above table refers to Fig. 66, page 173.

Planers of 48″ capacity and over have power lift to cross head.

Planers of 30″ capacity and over can be fitted with two saddles on cross head.

Planers of 36″ capacity and over can be fitted with vertical slides on one or on both uprights.

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PLANING, SLOTTING, AND SHAPING MACHINE COMBINED.

Arranged with a stroke of 24 feet when used as a planer; with a stroke of 12 feet as a slotter, and of 6 feet as a shaping machine. The work to be planed is secured to substantial foundation plates, and remains stationary. The planing tool moves over the surface to be dressed. Work of any size may be presented to the machine, and the areas planed will be included in a space of 24 feet by 6 feet horizontal by 12 feet in height,—*i.e.* within a space of 1728 cubic feet. Each motion of the machine is independent of its other motions, and in each of its capacities of planer, slotter or shaper it is provided with independent hand and automatic feeds in all directions, with independent tool-lifting device, to raise the point of the tool on its back stroke.

An adjustable automatic stop motion is provided in the machine, regulating the stroke as required by the work. This is as easily set as the stops in an ordinary planer-table.

Platform to carry the workman, provided with all conveniences, to enable him to handle all the feeds within easy reach of cutting tool. Vertical slide and tool-apron, adjustable to three positions on the shaping bar, thus enabling the cutting tool to be presented to the work under the best possible conditions.

Speed of planer, 18 feet per minute travel under cut; 36 feet per minute on the back stroke. Machine driven by an endless belt over two countershafts, one at either end of its planing movement. Fast pulleys on countershaft 32-inch diameter, 8-inch face, which should make 235 revolutions per minute.

A crane and hand-hoisting gear is provided, for the ready handling of the vertical slide and tool holder.

THIS immense tool was completed in March, 1877, after nearly two years' work, and possesses many novelties in its construction. It was designed to fill a want long felt in shops where large engineering work is constructed, viz., to supply a means of dressing work too large to go on to ordinary planing machines. Examples of this kind occur continually in practice, and much ingenuity has been exercised in devising means to accomplish such work with existing tools, while some desirable forms of construction have been rendered impossible for the want of such a machine tool as this.

Purpose of the tool.

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Difference between it and other movable tool planers.

Planers have been constructed to operate horizontally or vertically with a movable tool over the face of work presented to it, but the distinctive difference between this machine and any other is that it combines with the horizontal and vertical movement on one plane a horizontal one of six feet at right angle to the first. It also meets all the requirements of a perfect machine easily and economically worked, and is not a make-shift to accomplish in a manner part of the required work.

Character of work it will do.

Bed-plates of marine engines, or other similar work placed within reach of this tool, may be dressed in all required parts—up, down, across, or at any angle—with the same ease as smaller work can be done on either a planer, a slotter, or a shaping machine.

Description of machine.

The planing machine is sustained on a carriage resting in V's, as in an ordinary planer. The work is secured to heavy foundation plates in front of the machine.

Size of bed.

The bed upon which the carriage moves is 38 feet long by 9 feet wide, the slide V's being 8 feet from centre to centre. The frame of the carriage where it rests in the V's is 14 feet long. Upon this carriage at one side of it, nearest to the work to be planed, stands an upright about 16 feet high. This upright is firmly braced by diagonal cast-iron braces to the carriage. Upon the face of the upright moves a well-guided frame, which is the saddle of the cross-slide or shaping bar. The motion up and down of the frame on the upright constitutes the slotting movement; the motion of the shaping bar across the face of the upright constitutes the shaping movement; the motion of the carriage on the bed gives the planing movement. To the slotting-saddle on the upright is attached a

Slotting motion.

Shaping motion.

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platform; upon this the workman stands. The platform is surrounded by a hand-rail, and easy access to it is obtained by steps on the frame of the machine.

Platform and feed motion.

Upon this platform all the devices used in operating the various feed motions are arranged within easy reach. Here the workman can start or stop the machine, can make any of the feed movements either by hand or power, can adjust the amount of power-feed, and, in fact, can thoroughly control the machine in its performance of any one of its functions.

How it is driven.

Motion is conveyed to the machine by an endless belt, which passes from the main countershaft overhead to a guide-pulley on top of the upright of the machine; thence down to the driving-pulley on the carriage; thence up over another guide-pulley, and then to a second counter at the extreme end of the stroke of the machine, and so back to the first counter, forming, say, a continuous belt of about 100 feet in length. The driving motion of the planer, apart from this long belt, is precisely similar to that on our improved planers. The shaft on the machine, driven by the long, endless belt, is, in fact, the true countershaft of the machine; from pulleys on this, open and crossed belts drive the fast and loose pulleys of the machine for the forward and back motions. The belt-shifting device being the one so well known, and so successfully used on our other planing machines. The driving-pulleys transmit power to three shafts within the bed, which radiate from a common centre. They are united by bevel wheels next to the fast and loose pulleys; the central shaft of this system carries power to the screw which works the slotting device; the one to the right of this gives motion to the machinery for operating the plan-

Fast and loose pulleys.

Belt shifter.

Driving shafts

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ing mechanism, and the one to the left carries power to the shaping machinery. All of these shafts are also geared to upright shafts, which extend through the foot-board, and these in turn are under the control of the feed motion. Sliding clutches on the horizontal shafts connect and disconnect the various motions in such a manner as to render possible the connection of each one of the principal motions to the driving machinery, all others being feed motions, so that when the planing motion is in gear the slotting and shaping motions are under control of the feed motion, and so with each distinct motion in turn.

Independence of the various motions.

Crane.

A very convenient crane attachment is provided, to facilitate the ready placing of the slide, which carries the tool in any required position.

Stop motion.

From the platform the machine can be worked by hand, but the automatic stop motion, adjustable by nuts on a long screw, permits the ready setting of the stops, which reverse the machine by power.

One exhibited Paris Exposition.

Previous to the Paris Exposition we built a very large planer with movable tool. This was exhibited at Paris in 1867, and was afterwards sold into Holland. The present tool has been designed as an improvement over the first one, having a very much more extended scope. This machine was built to fill an order from the Russian government, and placed in the Navy Yard at Cronstadt. Its utility is unquestionable. Its power of cut fully up to all possible requirements. For marine work, the uses to which it can be applied are numerous. The great ease with which it can be handled, and its exceeding rigidity of structure, render it a very useful tool, even when applied to work which might be dressed on the table of an ordinary planer or worked on shaping or slotting tools.

Built for Russia.

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Fig. 67.

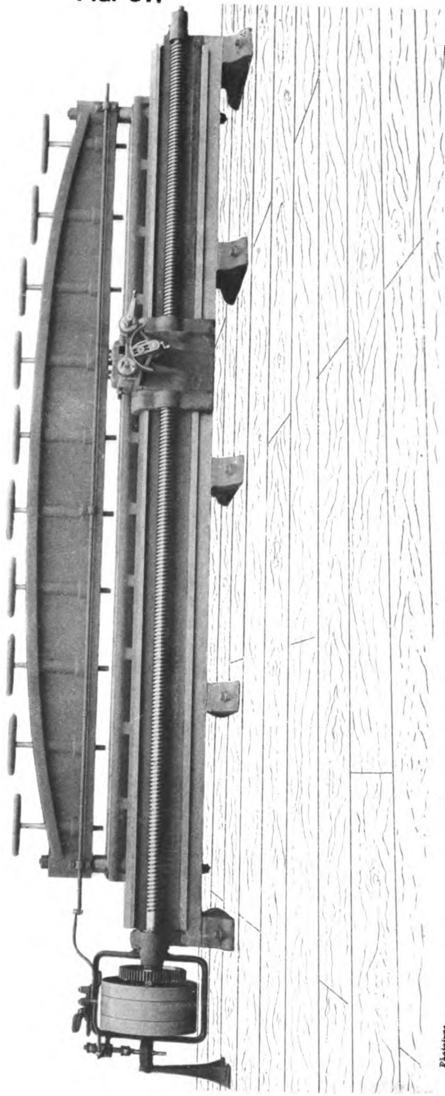

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PLATE PLANING MACHINE.

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FIG. 68.

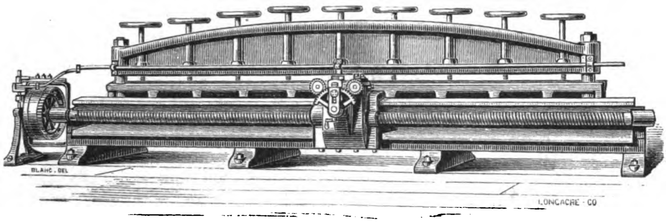
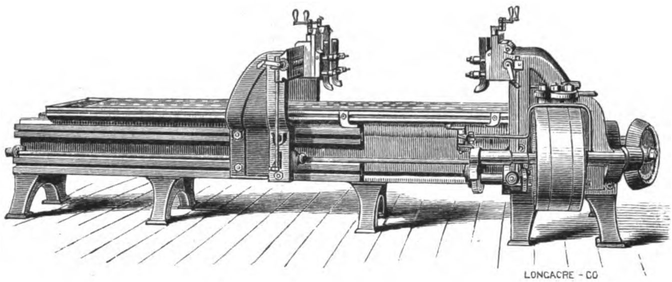


PLATE PLANING MACHINE.

Arranged with table to carry plate 16 feet long, with powerful holding-down bolts, clamping the sheet on a wooden bolster, which may be curved to form of ship plates. Cutter head driven by screw, carrying two tools, taking cut both ways and self-operating in feed. The feeds vary from $\frac{1}{100}$ of an inch to $\frac{1}{12}$ of an inch.

IT has been found that boiler plates, planed to a bevel on their edge, can be worked with more certainty and make much better work at a very much less cost than if chipped by hand. It was thought that the same result might be obtained by using bevel shears which should cut the edge on an angle, but the work done by them was found to be so ragged as to be practically worse than if left square. The Plate Planing Machine bevels the edge and squares up a narrow calking surface. For building For ship work.
iron ships this machine is invaluable, it being able to plane the sheets either before or after being bent. The shifting of the belts for reversal of motion of machine is effected by a feed rod in front of the large clamp bar, when the reversal is made by hand. At the pulley end of machine there is an adjustable stop-motion, which can be set to the required length of sheet to be planed. Fast and loose pulleys on counter 16 inches diameter, 6¼ inches face, speed 280 revolu- Speed.
tions per minute.

FIG. 69.



ROD PLANER.

For planing locomotive connecting rods, arranged with two sets of uprights and cross heads, with double saddle on each cross head. Table driven by spiral pinion driving gear, so arranged as to move table at same speed each way, and, taking cut in both directions, is adjustable in length of rod to be planed from 3½ to 12 feet. Self-operating feed to saddle. Will plane both ends of two connecting rods at the same time. Fast and loose pulley on counter-shaft, 14 inches diameter, 4 inches face, should make 236 revolutions per minute. Ball and socket hangers for over-head shaft; wrought iron work planed to standard sizes and case hardened.

A SPECIAL tool designed for use in locomotive shops; useful in planing the ends of connecting rods, but is applicable to all kinds of stub-ends for stationary-engine work as well; can also be used for planing guide bars for locomotives, in which case it will work to advantage on four guide bars at once. It is a solid, substantial tool, capable of taking same cut as our regular 30 inches by 30 inches planer, and has all the advantages of our patent planing machine. In using this machine for a long time on short

Spiral pinion.

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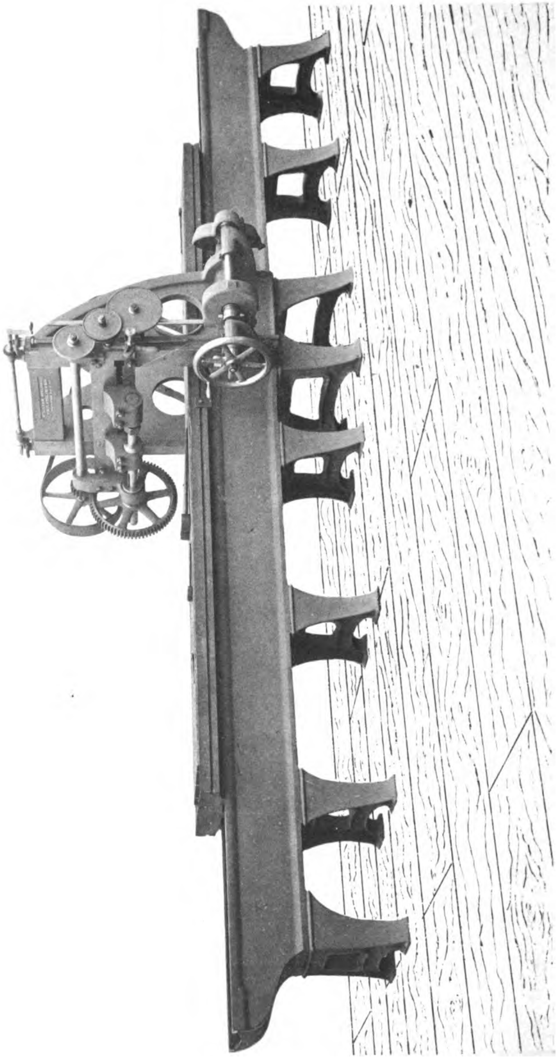
FIG. 70.



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SLABBING MACHINE.

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strokes it is advisable (as with any planer) to pay more attention to the oiling of the V's than if it was on long work, as at short strokes the oil is not so well distributed by the self-oilers; so an occasional examination of the spiral pinion, to see that it is greasy (not slushed with oil), is advisable. **Oiling the ways.**

The introduction of this machine has materially cheapened the production of locomotive connecting rods and similar work. Speed of counter same as for 30 inches by 30 inches planer, viz., 236 revolutions of fast and loose pulleys, which are 14 inches diameter, 4 inches face.

SLABBING MACHINE.

Arranged with bed, tables, and uprights, like planer, with a capacity of 25 inches by 25 inches; table 12 feet long. Table operated by spiral pinion in same manner as on our patent planing machine. Spindle to carry cutter $4\frac{1}{2}$ inches diameter, 4 inches wide, powerfully geared, and adjustable in height.

THIS tool is especially adapted to mill the flats of connecting rods and similar work. When used for cutting cast iron, larger cutters than $4\frac{1}{2}$ inches diameter can be used to advantage. The feed is variable between the extremes, and the table has a means of moving it readily by hand, with an automatic stop motion to throw out the feed at the end of the stroke. The table is provided with a dish extending entirely around its edge, to catch the water used in cooling the cutter. The fast and loose pulleys on the machine are 20 inches diameter, 3 inches face, and should make 114 revolutions per minute. **Variable feed.**

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SHAPING MACHINE.

(*For Report of Judges, see page* xvii.)

With shaping bar moved by variable crank, with quick return motion; feeds in all directions; motions for straight, curved, vertical, and angular work, and internal curves; the planing tool moving in every direction, and the work stationary. Tool holder, with segment wheel and worm, two tables for holding the work, adjustable, longitudinally and vertically; over-head shaft, pulleys and ball and socket hangers; cone pulleys, turned inside so as to be perfectly balanced; a full set of wrought iron wrenches, and all wrought iron work finished to standard sizes and case hardened.

With stroke of bar 9 inches to plane, in length 36 inches.
" " " 12 " " " " 48 "
" " " 16 " " " " 66 "

Centre head on bar with index plate.

Clamping vise.

Double shaping machine, two beds on one base, casting for connecting rod planing, can be furnished.

Revolving hollow spindle in bed, to carry mandrils and cones for circular work, furnished only to order.

Name of Shaping Machine.	Counter-shaft, with two sets of fast and loose pulleys.			
	For Short Stroke.		For Long Stroke.	
	Speed.	Diameter of Fast and Loose Pulleys.	Speed.	Diameter of Fast and Loose Pulleys.
9″	400	6″ × 2½″	150	10″ × 2½″
12″	200	9″ × 4″	66	16″ × 4″
16″	380	10″ × 4″	135	18″ × 4″

THE shaping machine, called sometimes compound planer, is one of the modern machine tools of such great convenience and universal application that it has become essential even in shops of limited

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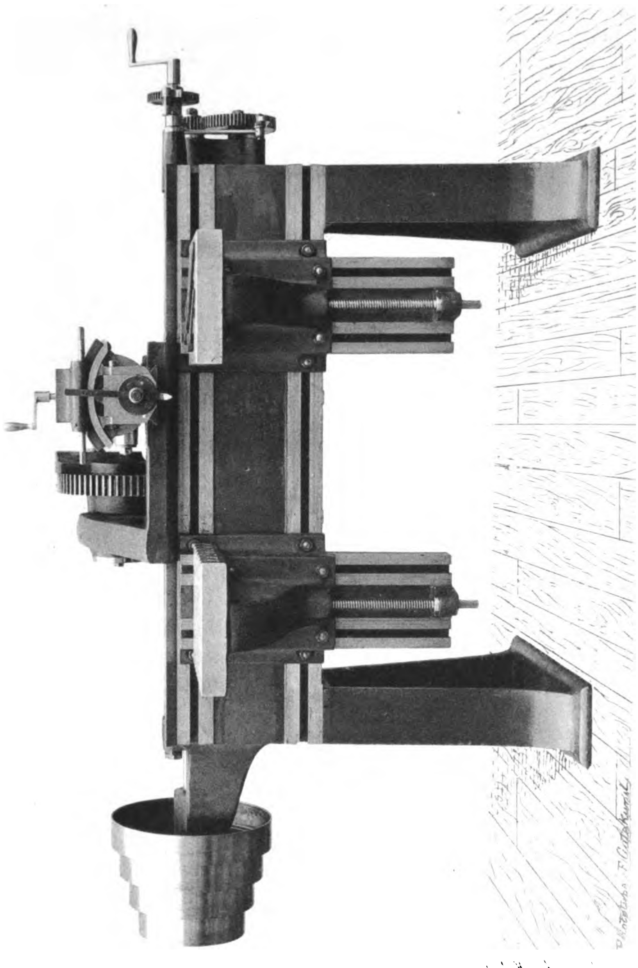
FIG. 71.



Phototype. F. Gutekunst. Philadelphia.

12-INCH SHAPING MACHINE.

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capacity. The manner in which it performs its work—viz., the work being stationary and the tool held on the end of projecting bar being made to move—involves conditions requiring unusual care in design and construction.

Work stationary.

The peculiar device invented by Mr. Whitworth, of Manchester, England, and first applied by him to these tools, of so arranging the driving crank motion as to give a slow motion of tool under cut and a quick return, has come to be universally acknowledged as the proper means of operating the planing tool. Our shaping machine has this so-called Whitworth motion, constructed in such a manner as to make the cut in about two-thirds of the revolution of crank wheel and the return stroke in the remaining one-third of a revolution. We have retained all the essential particulars of the machine as made by Mr. Whitworth and added many conveniences, adapting it to a wider range of work, increasing its power of cut, and so arranging the driving power and feed as at all times and in every motion to insure the feed occurring at end of stroke, and never under cut. This is an important feature. The machines, when built, are submitted to rigid examination and tests to be sure that they plane true in square and in parallelism, errors being more apt to creep into this class of tools than in any other, so that users will find that the extra cost required to produce a machine which is correct in adjustment and in work is amply compensated for in excellency of performance. The counter-shafts of these machines are each arranged with two speeds, one fast one for short work, and one slow one for greater length of cut, and for planing steel. These differences of speed are in addition to the changes incident to the cone pulleys.

The Whitworth motion.

Quick return to tool.

Feed always at end of stroke.

Inspection of tools.

Speeds.

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Counter-shaft. Our 9-inch shaping machine has on its counter 6 inches by 2½ inches fast and loose pulleys, which should make 400 revolutions per minute, and a pair of 10 inches by 2½ inches fast and loose pulleys, which should make 150 revolutions.

Speed. Our 12-inch machine has 9 inches by 4 inches, fast and loose, 200 revolutions, and 16 inches by 4 inches, fast and loose, which should make 66 revolutions.

Our 16-inch machine is provided with 10 inches by 4 inches, fast and loose, to run 380 revolutions, and 18 inches by 4 inches, fast and loose, to run 135 revolutions.

Clamping vise. We also make clamping vises, adapted to each size of machine, for the convenience of holding many kinds of work; but in large establishments, where there is a repetition of planing on the same kind of work, it is customary for the user to adapt to his work special holding devices.

Spindle for curved work. The machines may be provided with a spindle and chucking cones, for doing circular work, such as planing up the bosses or hubs of rocker arms; this device is extra. Much work can be more conveniently held in independent centre heads. We arrange centre heads for each size of machine, with index plates carefully divided, and with tangent wheel and worm for feeding on circular work. These centre heads are supported on a bar, so arranged as to be held in line or at right angles to the planer motion. Both the clamp vise and centre heads are classed as extra tools, and not included in the price of the machine, inasmuch as where several shaping machines are used in one shop, it is not always deemed advisable to furnish each with a full set of extra tools.

Centre heads. Extra tools.

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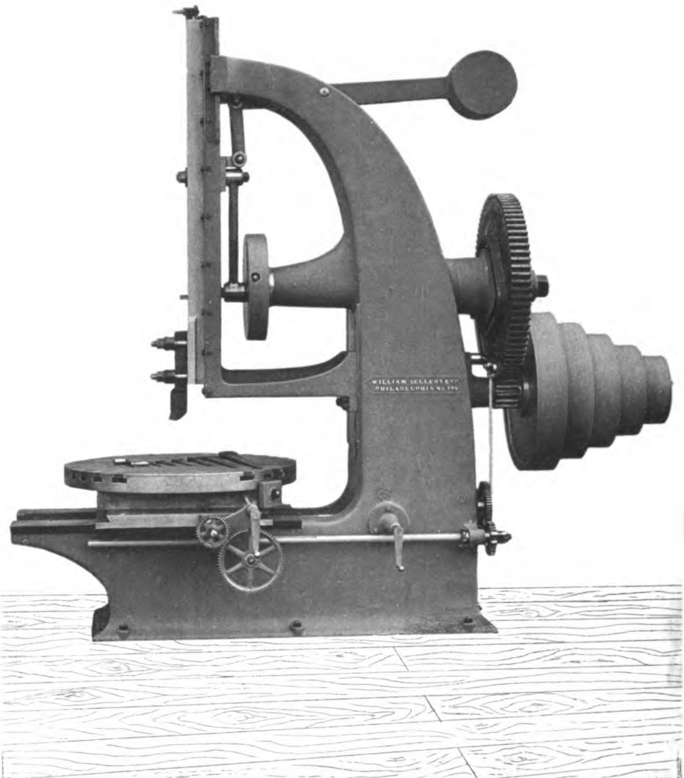
Fig. 72.



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72-INCH SLOTTING MACHINE.

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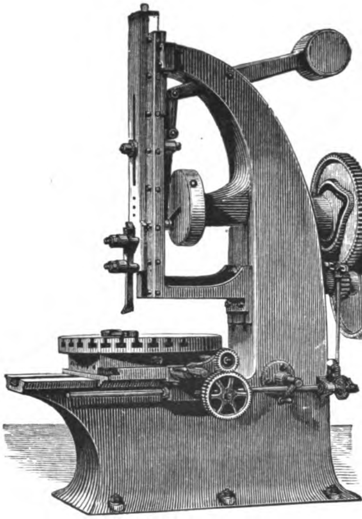
FIG. 73.



SLOTTING MACHINE.

With slotting bar counterbalanced so as to run without jarring; is driven by a variable crank, with quick return motion; bearing for slotting bar adjustable vertically, to suit the different heights of work; compound tables with circular plate and centering stud; feeds self-acting in all directions; over-head shaft, iron cone pulleys turned inside, so as to be perfectly balanced; ball and socket hangers, and wrought iron wrenches. Wrought iron work case hardened.

Name of machine indicates the diameter of wheel that can be splined. Face of tool is half the named size of machine from the face of the upright.

Size of Machine.	Diameter and Face of Fast and Loose Pulleys.	Revolutions per Minute.
30 inches.	10 inches by $2\frac{3}{4}$ inches.	260
36 "	12 " " $3\frac{1}{8}$ "	224
42 "	14 " " $3\frac{1}{2}$ "	204
48 "	16 " " 4 "	184
60 "	20 " " $4\frac{1}{2}$ "	157
72 "	24 " " 7 "	130

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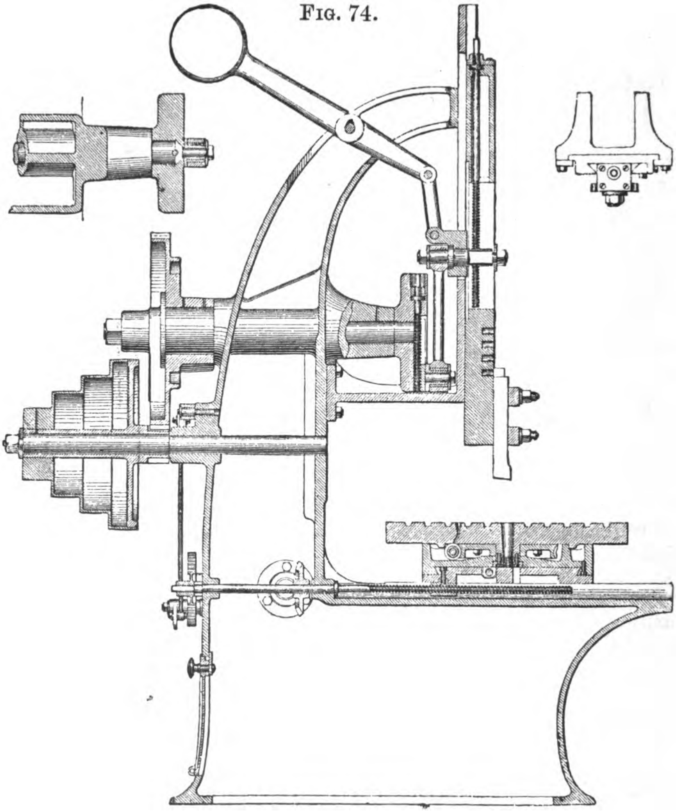
Fig. 74.



SLOTTING MACHINE.

To	admit	30	inches	diameter.	7½-inch	stroke.	
"	"	36	"	"	9	"	"
"	"	42	"	"	10½	"	"
"	"	48	"	"	12	"	"
"	"	60	"	"	15	"	"
"	"	72	"	"	18	"	"

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SLOTTING MACHINES.

(*For Report of Judges, see page* xvii.)

THESE machines, as in the case of our shaping machines, are provided with the so-called "Whitworth motion" to the slotting bar, giving a slow movement under cut and a quick return motion. They are adjustable in length of stroke and in position of the slotting bar in height from the table upon which the work rests, and the bearing or slide in which the slotting bar works is also adjustable, to suit the different heights of work and to enable the bar to be guided as near to the work as possible, thus giving great steadiness to the motion. In some kinds of work this adjustable bearing may be set down near to the table, and thus give a firm backing to the tool during the whole of its stroke. The slotting bar is counterbalanced; this effectually prevents jar in running, the lost motion being all taken up by the counterweight in the direction of the force exerted in making the cut. The compound table is provided with a circular table, operated by wheel and tangent screw with self-operating feed. An important feature of this machine is the arrangement of its feed motion, which insures the feed always occurring at the top of the stroke and never during the cut. The great advantage of this will be manifest when it is remembered that should the feed occur at lower end of stroke the rigid tool will drag back with a pressure due the amount of feed. The working handles to operate feed by hand are on all these machines, even on the largest size, within easy reach of the workman, and in

Whitworth motion.

Adjustable bearing.

Slotting bar counter-balanced.

Table.

Feed.

Handles.

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such a position as to enable him to readily see the point of the slotting tool as he adjusts the feed,—an advantage quickly appreciated when the machine is used to slot to scribed lines. Apart from the stability of the machine, and the great care taken in the con-

Advantages. struction, these machines possess advantages over any other style we have seen, doing more and better work with the same grade of workman. This advantage obtains mainly from the exceeding convenience of handling. There is scarcely any machine tool requiring more close watching on the part of the workman on the class of work it is required to do; it seldom takes long cuts, it generally being but a little while under power feed at a time, and then its amount of production, all other things being equal, depends upon the readiness with which the attendant workman can do his part of the movements in adjusting and re-adjusting the work in various positions and keeping the tool under cut as much of the time as possible.

For speed of counter-shaft of the various machines we give the following table:

Size of machine.	Diameter and Face of Fast and Loose Pulleys.	Revolutions per Minute.
30 inches	10 inches by 2¾ inches	260
36 "	12 " " 3⅛ "	224
42 "	14 " " 3½ "	204
48 "	16 " " 4 "	184
60 "	20 " " 4½ "	157
72 "	24 " " 7 "	130

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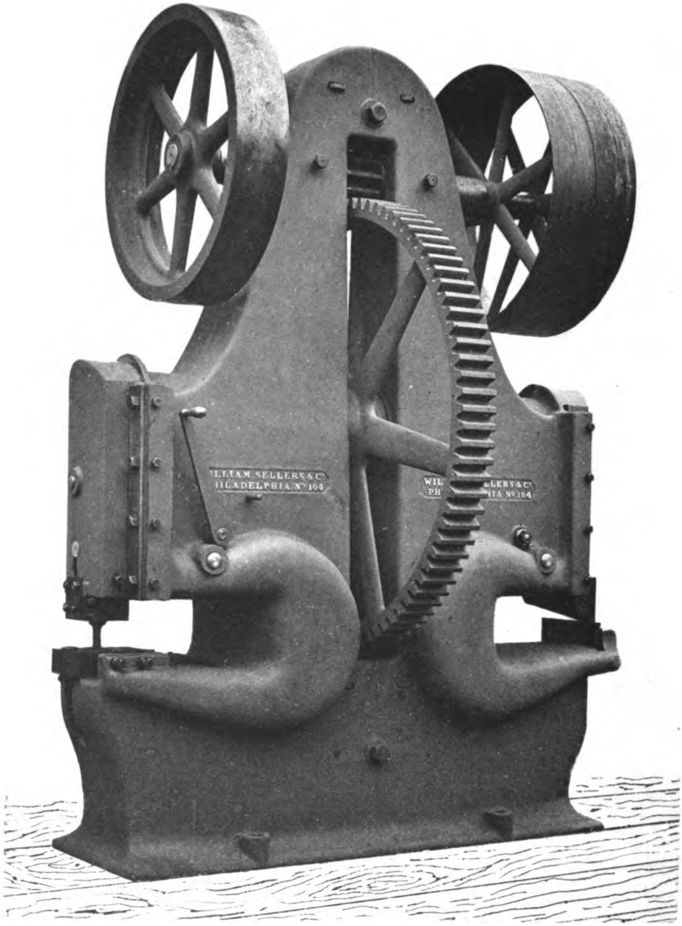
Fig. 75.



PHOTOTYPE BY F. GUTEKUNST.

PUNCHING AND SHEARING MACHINE COMBINED.

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PUNCHING AND SHEARING MACHINE COMBINED.

(*For Report of Judges, see page* xix.)

Punch and shears driven from the same shaft; independent stop motion to each, so that they will always rest at their highest point; can punch a 2-inch hole in the centre of a $\frac{5}{16}$-inch plate $35\frac{1}{2}$ inches in diameter, and can shear $\frac{3}{4}$-inch plates in width $20\frac{1}{2}$ inches; overreach of jaw 20 inches for rivet punches and shears, and $17\frac{3}{4}$ inches for washer punches.

IN designing this machine the requirements of ordinary boiler work were kept in view. The shear is intended for cutting plate iron of usual thickness for boilers; will shear $\frac{3}{4}$-inch plate. The punching side has its dies so arranged in a holder as to permit the punching of flanges of boiler heads which are as small as 12 inches in diameter; the punching being done from the outside or marked side of the head, and flanges turned out on end of flues can be punched vertically. We send with each machine a sample set of punches and dies intended for boiler plate of $\frac{3}{8}$-inch thickness, on which it will be seen that the holes in the dies are made larger than the punches by the following formula, expressing the diameter and thickness in sixteenths of an inch.

Punching boiler heads.

Sample punches and dies.

The diameter of the die hole = diameter of punch, plus $\frac{2}{10}$ the thickness of the plate ($D = d + 0.2\ t$). Thus, for iron plate $\frac{6}{16}$ of an inch thick, the diameter of the punch being $\frac{13}{16}$ of an inch, the diameter of the die hole will be 14.2 sixteenths of an inch,—say $\frac{7}{8}$ inch. This method of making the die hole larger produces a taper hole in the plate, but allows the punching to be done with less consumption of power and, it is said, with less strain on the plate. We do not adapt any strippers to this machine, as the character of work makes it necessary for the users to arrange them to suit their special work. To run these

Formula for size of die hole.

No strippers sent with machines.

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machines efficiently, the fast and loose pulley on the machine should make at least 120 revolutions per minute: this will punch 12 holes to the minute; if a faster speed is admissible on the work, the speed of pulleys can be increased. Determine number of punch strokes to the minute, and multiply by ten for speed of pulleys. By means of the independent stop motion, one stroke can be made at a time on either side of the machine without stopping the machine itself, or interrupting the work being done on the other side. In this respect it is as convenient as two entirely distinct machines.

Speed.

We can arrange it also with punch in place of the shear blades. It is then a double punching machine, admirably adapted for punching nuts, the holes in the bar being punched on one side of the machine and the nuts punched out on the other side.

Double punching machine.

The power of this press is sufficient to punch a 2-inch hole in $\frac{5}{16}$ iron plate, and to shear $\frac{3}{4}$-inch plate.

We also arrange from same pattern a punch and shear with less overreach; the shear blades placed for cutting off light bar iron, and the punch side arranged for washer punching, or the punching of $\frac{3}{4}$-inch thick bars for car work. When single punches or shears are required, we can stop off part of the frame and produce independent machines, useful for some special purposes, when it is required for convenience to have the punch and shear in separate parts of the workshop.

Crank motion punching machine.

The punching machine alone arranged in this manner has frequently been used for punching rail ends, and may also be advantageously employed as a washer punching machine.

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PUNCHING AND SHEARING MACHINES OPERATED BY LEVER.

WE have introduced various punching and shearing machines arranged with a heavy wrought iron lever to work the vertical slide. The lever being moved by a cam on the driving shaft. This form of machine we recommend for the following reasons:

It is evident that in all punching or shearing machines driven by a belt, there must be a conversion of the rotary motion of the driving pulley into a reciprocating motion of the punch or shear blade.

To obtain the requisite power, many revolutions of the driving pulley must occur to one stroke of the punch. In crank machines, the whole pressure of the cut comes directly on the crank pin, which must perform a good portion of its revolution under this heavy strain at whatever speed the crank shaft may be running. This limits the power of such machines to the practical pressure sustainable on a given surface at a given velocity. When the vertical slide which carries the punch is operated by a lever, the sliding motion of the part of the lever in contact with the vertical slide is almost inappreciable: the pressure extends over large surface with little motion; so with the fulcrum pins over which the lever works; with very little and very slow motion of these parts much pressure is admissible, while the long end of the lever is operated upon by the lifting cam acting under comparatively light pressure. Added to this economical use of power, with diminished frictional resistance, comes the possi-

Pressure on crank.

Less friction with lever machine.

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bility of so shaping the cam which lifts the lever as to cause the motion of the punch to be uniform through the whole length of the stroke, to return quickly, and then to dwell during any required portion of the revolution of the cam-shaft at the top of its stroke. Therefore, in comparing machines using the crank or eccentric with those employing the lever and cam, if in both cases the same pulley, belt, and gearing is used, running at the same rate of speed, and making the same length of stroke at the punch or shear blade, it will be found that there is a capability of punching larger holes or of shearing thicker plates when the cam and lever are used than when the crank or eccentric is employed.

Quick return to punch.

Lever machine less friction than the crank.

On the lever punch and shears, as now made by us, is arranged a four-toothed clutch on the main shaft, to be used in stopping and starting the plunger. This admits of quicker work than when the cam is shifted on the main shaft. The tail end of the lever is made to drop on a block of wood held in a box at the back of the machine, and the adjustment of the length of block to limit the fall of the lever enables the stroke to be controlled, and in thin metal to carry the punch close to the plate with less drop than when thicker iron is being punched, so obtaining a longer dwell for setting the plate.

Clutch to stop the motion.

Regulation for the stroke.

We have quite recently added important improvements to all our punching and shearing machines in the direction of increased strength and greater efficiency, much extending their range of usefulness. Prominently among these improvements we will mention, so arranging the lever machines as to make them, when desired, do the punching and shearing on one and the same machine. Heretofore all attempts

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at an interchangeable single punching or shearing machine have been unsatisfactory. Shearing machines with punching attachments have been made, but one or the other device has been at the best a make-shift, not very satisfactory and yet useful, inasmuch as it has enabled one machine to do both kinds of work where there is not enough of both kinds to make the purchase of separate machines advisable. To meet this want we have now perfected interchangeable machines, which can be used for either kind of work, and when in use for either is at that time perfect in all its appointments, as much so as if built for that purpose only. The change from one to the other is as readily effected as the change of blades in a shearing machine or of punches in a punching machine.

Interchangeable lever machines.

Improved punch or shears.

While we do not fit up all these machines to be interchangeable, the extra cost of the machines so arranged is so little above the cost of the machines for one kind of work only, that it may be in some cases quite advantageous to use these machines where independent machines are employed, as they can then be, any or all, used on whatever work is the most pressing. To aid in the selection of the machines for various purposes which we make with levers in one housing, we append a list, with their capacities, before describing them in detail.

Advantages.

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LEVER SHEARING MACHINES.

Shearing machine, 26 inches over-reach, will shear plates $\frac{15}{16}$ inch thick.

Shearing machine, 33 inches over-reach, will shear plates $\frac{5}{8}$ inch thick.

Shearing machine, $23\frac{3}{4}$ inches over-reach, will shear plates $1\frac{1}{2}$ inches thick.

Bar shearing machine, capable of cutting iron 6 inches by $1\frac{1}{2}$ inches.

Plate shearing machine, with 12 inches stroke, making cut 60 inches long, capable of shearing 1 inch iron plate, over-reach for edges of long plate 7 inches, will cut across plates 5 feet wide at any point of their length.

Lever shear for angles, will cut 6 inches by 6 inches by $1\frac{1}{2}$ inches angles square without spoiling the crop end.

LEVER PUNCHING MACHINES.

Lever punching machine, with 26 inches over-reach, will punch 2-inch hole in iron $\frac{1}{2}$ inch thick.

Lever punching machine, with 33 inches over-reach, will punch 2-inch hole in iron $\frac{1}{2}$ inch thick.

Lever punching machine, with 22 inches over-reach, will punch 2-inch hole in iron $1\frac{1}{2}$ inches thick.

Bar punching machine, with 7 inches over-reach, will punch 2-inch hole in iron $1\frac{1}{2}$ inches thick.

LEVER MACHINES FOR EITHER PUNCHING OR SHEARING.

With 26 inches over-reach, shearing $\frac{15}{16}$ inch iron plates and punching 2-inch hole in iron $\frac{1}{2}$ inch thick.

With 33 inches over-reach, shearing $\frac{15}{16}$ inch iron plates and punching 2-inch hole in iron $\frac{1}{2}$ inch thick.

Bar shear, to cut 6-inch by $1\frac{1}{2}$-inch iron and to punch 2-inch hole in iron $1\frac{1}{2}$ inches thick.

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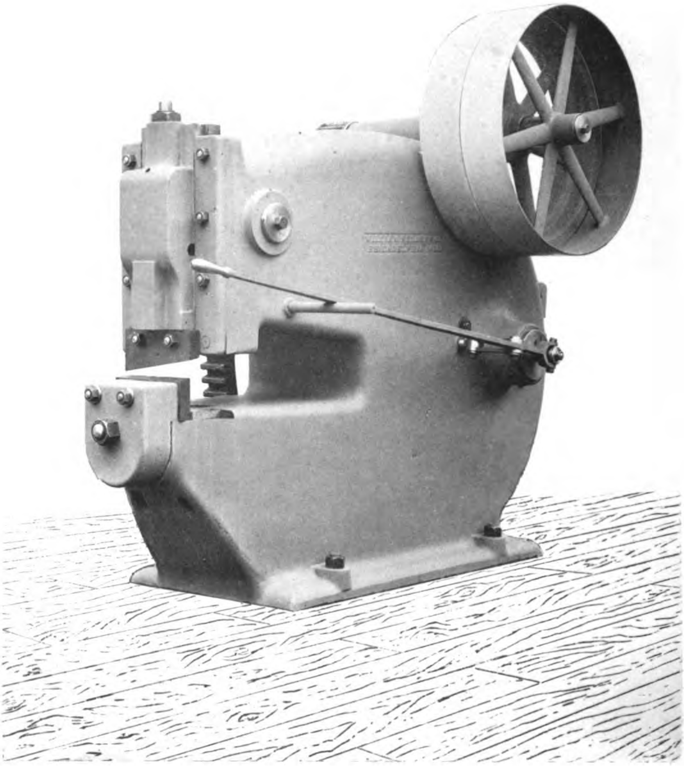
FIG. 76.



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SHEARING MACHINE, 26 INCHES OVERREACH.

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SHEARING MACHINE.

Shear blades placed so as to be right for trimming edges of plates, not for cutting bar iron. Operated by a heavy wrought iron lever within the housing. Independent stop motion by means of a four-toothed clutch in the housing. Blades rest open when clutch is out of gear. Vertical motion of blades 1½ inches. Can be used to shear plates of iron $\frac{15}{16}$ inch thick. Fast and loose pulleys on the machine 36 inches diameter, 7 inches face, which should make 114 revolutions per minute.

We make two sizes of this machine, namely:

Shear, with 26 inches over-reach, to slit through the middle plates 52 inches wide.

Shear, with 33 inches over-reach, to slit through the middle plates 66 inches wide.

FOR remarks on the theory of the operation of these machines, see page 201. The heavy wrought iron lever in the housing raises the blade by its gravity, and the cam which moves the lever is so shaped as to cause the motion of the blade in cutting to be at a uniform rate of speed. Returning quickly it dwells for some time at the top of its stroke, thus giving ample time to shift the plate for the next cut.

Motion of blades uniform.

In our earlier machines we moved the lifting cam sideways from under the lever when it was desired to stop the machine. This could only be done when the cam was free from pressure at the end of the stroke, and in starting again the cam could only be pushed in when in proper position in regard to the lever. We now keep the cam in position under the lever and attach it to or detach it from the shaft by means of a four-toothed clutch, which while it can only be withdrawn at the completion of the stroke, yet at the same time it will permit the starting again to be effected in

Shifting cam.

Stopping by means of clutch.

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any one of four positions of the driving wheel in relation to the cam, thus saving much time and also preventing the damage to the machine likely to arise from working the cam only partly under the lever.

SHEARING MACHINE FOR 1½-INCH PLATES.

Shear blades placed so as to be right for trimming the edges of plates, not for cutting bar iron. Operated by heavy wrought iron lever within the housing. Independent stop motion by means of a four-toothed clutch in the housing. Blades rest open when the clutch is out of gear. One pulley only on the machine, 42 inches diameter, 12 inches face, making 120 revolutions per minute. The belt should be double.

THIS tool is admirably adapted for plate-work in car-shops, and is the mate to a punching machine, see page 229, which is for iron of the same thickness, and these machines cover much of work on draw irons and the like. It is usual to place these machines near to the main line and drive direct without any counter-shaft, as the blades can be stopped by the clutch in the machine. For repairs it is simpler to throw off the belt than to provide any means of shifting the belt. This and similar shearing machines or punching machines can be operated by an engine attached to the machine when such application is desirable. The manner of attaching the engine is shown on page 226.

No counter-shaft.

Engine attached when required.

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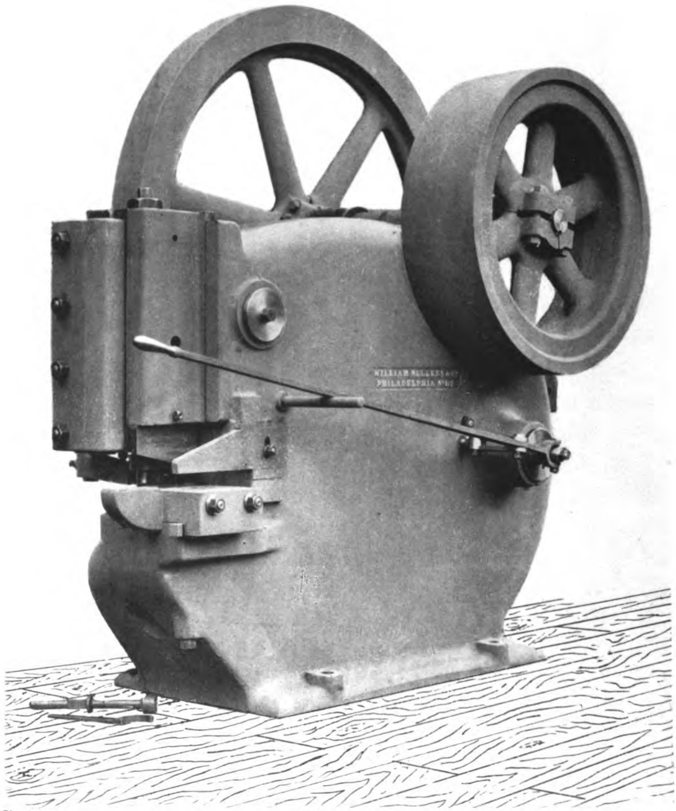
Fig. 77.



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BAR SHEARING MACHINE—WITH PUNCHING ATTACHMENT.

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BAR SHEARING MACHINE.

Shear blades placed so as to be right for cutting bar iron and not for trimming plates. Operated by heavy wrought iron lever within the housing. Independent stop motion by means of four-toothed clutch in the housing. Blades rest open when the clutch is out of gear. Is capable of cutting bars of iron 1½ inches thick and 6 inches wide at one stroke. One pulley only on the machine, 42 inches diameter, 12 inches face, which should make 120 revolutions per minute. The belt driving the machine should be double.

THIS has proved itself to be a very efficient tool for cutting bar iron. There is a rest provided on which the bar, resting at the required point of cut, can be pushed under the blades when open without stopping the machine, while, as in all our shearing and punching machines, a very convenient stop motion is provided. We fit the machine with plane blades only, but are prepared to furnish blades for cutting rounds when they are called for. The addition to this machine, of the punching devices already alluded to on page 202, makes it one of the most perfect tools for shearing and punching that has been designed, as each attachment is perfect in its way. We give on pages 226, 227, Figs. 83, 84, the bar shear, with the punching attachment shown, as operated by a special steam-engine attached to the machine. This engine is provided with heavy flywheel, and is capable of operating the punch to make holes 2 inches diameter in iron 1½ inches thick. The engine has a governor to regulate its speed to the required rate when the machine is running empty and to prevent its racing when through its cut. The examples we give of this machine will serve to show the attachment of an engine to any one of our punching or shearing machines without any further description.

See Fig. 77, page 210.

Engine.

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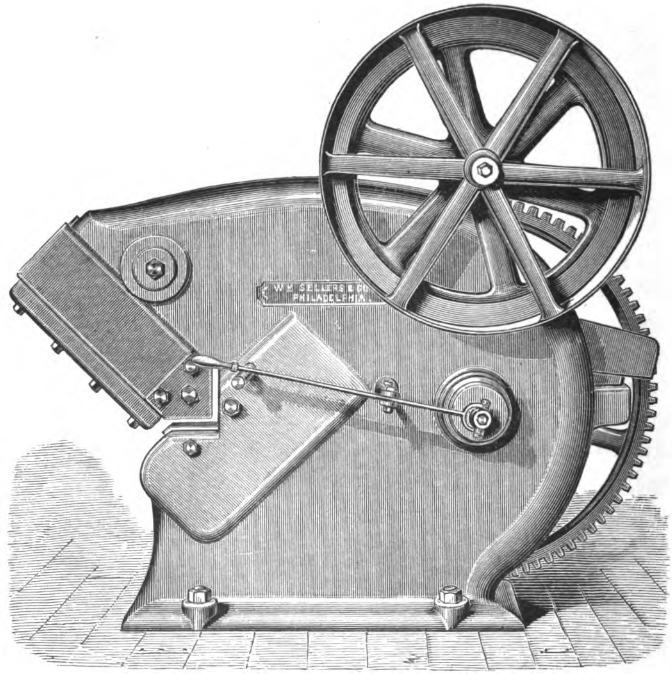
FIG. 78.



ANGLE SHEARING MACHINE.

(*For Report of Judges, see page* xx.)

Shear operated by a heavy wrought iron lever within the housing. Independent stop motion, so that the blades will rest open; lower blades in two pieces. Fast and loose pulleys on machine, 42 inches diameter by 7 inches face; speed, 144 revolutions per minute; will shear 6 by 6 inches by ½-inch angles.

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ANGLE SHEARING MACHINE.

THE same principle involved in all our improved lever shearing and punching machines obtains in this useful tool. Angles which have been curved or bent before shearing and while resting on trussels may be readily trimmed. The blades have no shear given to their edges; but by punching the angle off with a cut extending over all parts of the iron with a uniform pressure, the piece cut off is not bent out of shape. This is an important feature in the machine, as it enables it to be used in cutting up angles to length without distorting the ends cut off.

Does not distort the end.

It will be observed that the design of this machine is similar to our bar shear and our lever plate shear, as shown on previous pages, and indicates the practicability of adapting the frame of these machines to various purposes, as special punches or shears. We can widen the plunger, or vertical slide of the punching machines, and arrange adjustable punches for piercing four holes in fish plates at one operation. We are also prepared to make horizontal punches for fire-box and boiler-head work, convenient also for punching angle irons. We have also arranged some of our punching machines for the plates of coal screens; and to any of the punching machines we can adapt dividing machines to enable the sheets to be spaced mechanically, making proper allowance for the difference of diameter or circumference of outer or inner sheets in cylindrical boiler work.

Frame can be adapted to special purposes.

Horizontal punch.

Automatic spacing.

Very much more rapid work can be done when the plates are moved by a spacing device than when laid out with a template and passed through the machine by hand.

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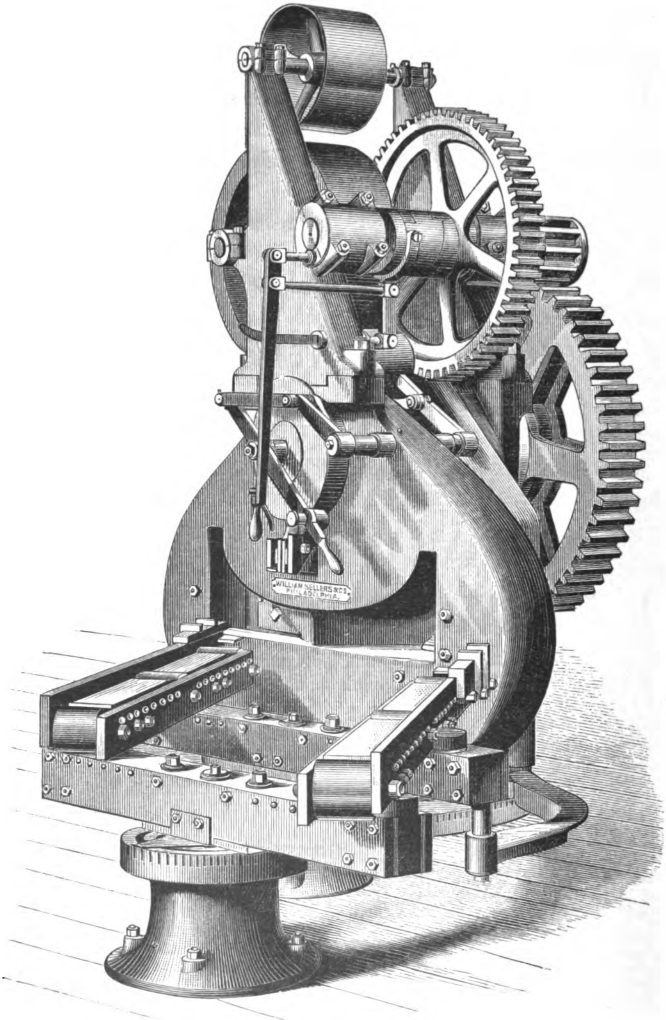
FIG. 79.



DUPLEX ANGLE SHEAR.

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DUPLEX ANGLE SHEAR.

Operated by heavy crank, which works either one of two diagonal slides carrying the cutting blades for right or left hand cutting. The bars are punched off at one stroke, so as not to distort the crop ends by any shearing motion of the blades, and the machine is powerful enough to cut 6 inches by 6 inches by 1 inch angles, and to make the cut at any angle required in bridge structures from 30° included angle to square. The machine is provided with guiding tables for the angles to rest on, and the entire machine, carrying its guiding tables with it, is made to swing on a centre, so that the presentation to the machine of the angle to be cut is always in the same right line. This arrangement is very economical of room, as the irons taken from the pile are presented in line with the pile, the machine being turned to the required angle of cut, either to the right or the left hand. Pulley on the machine is 36 inches diameter, 12 inches face, and should make 300 revolutions per minute. The machine must be placed under the driving pulley of the line, and the belt is so carried by guiding pulleys on the machine and near to the line driver as will permit the vibration of the machine to its required angle of cut.

THIS is one of the most important of our special tools for bridge building works. The great weight of the machine is carried on a set of anti-friction rollers, such as we use in our turn-tables for turning locomotives or for pivot bridges.

This enables the machine to be turned to the required angle of cut, thus setting the blades to the angle, and not swinging the bars to be sheared to the same angle. This is a very important matter, as involving great economy in shop-room. There are two shearing slides to carry the movable or upper blades, and these are at an angle of 90° to each other, so as to cut the angles as they lie on their flat with one leg vertical, and to make the cut at any required angle of oblique division, from 30° angle to 90°.

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Fig. 80.

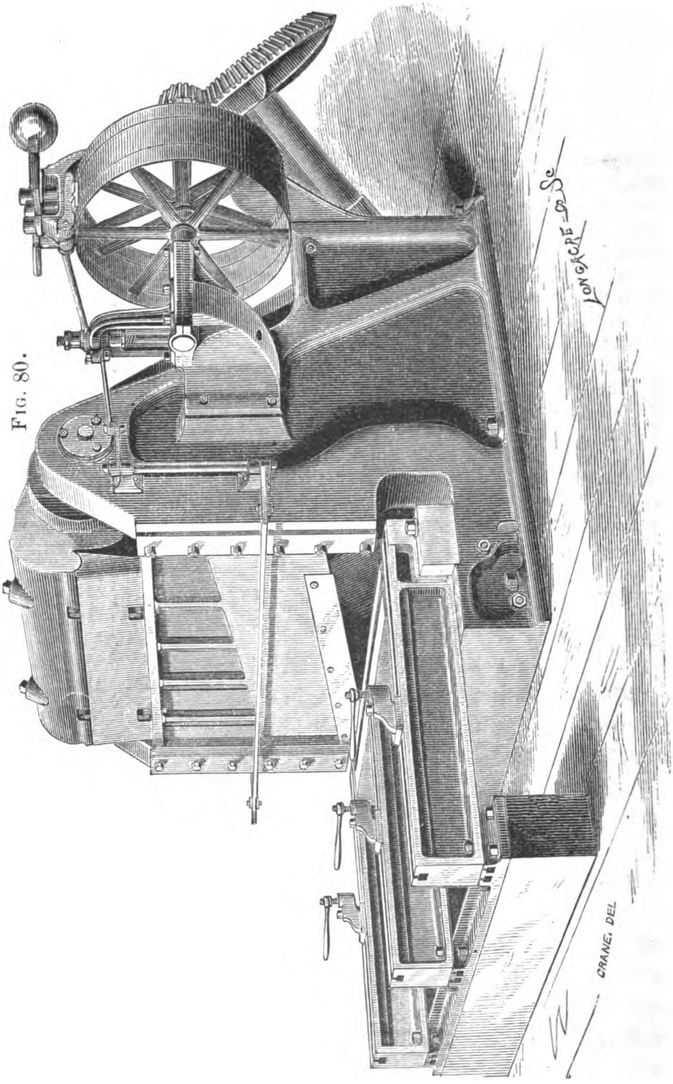

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PLATE SHEARING MACHINE.

(*For Report of Judges, see page* xx.)

For trimming edges of long plates, or cutting off to length plates 5 feet wide. Will shear wrought iron plates one inch thick. Upper blade guided vertically in the frame of the machine, and driven down by a pitman as wide as the blade is long; this pitman receiving its motion from a long rocking shaft above it. The driving arm or lever of the machine is a rack segment engaging with the teeth of a spiral pinion similar to the spiral pinion used in our patent planers. The spiral pinion is driven by bevel wheel and pinion and open and crossed belt, after the manner of planing machines. Cutting blade adjustable in length of stroke, returning at double the speed of its down stroke. Counter has 24-inch pulleys, 7-inch face, 272 revolutions per minute.

IN designing this machine, the wants of modern bridge construction and ship-building were in view. The plate clamped to place can be sheared with exceeding exactness, either in trimming the edge of long plates or cutting off plates 5 feet wide and under, to lengths. The driving device is new and very efficient. The blade being at all times under the control of the operator, can be made to cut to any fixed point in its length and then stopped or raised. It is provided with an automatic adjustment to its belt-shifting motion, gauging the length of its stroke. It makes the down stroke, immediately reascends, and stops up, to wait for the readjustment of the plate. A hand rod in front of the machine is convenient to shift the belts and start the cut.

Driving device. **Belt-shifter.**

The machine is so constructed as to have its strains all within itself, and is not in any great measure dependent upon stone foundations for its rigidity, other than the proper maintaining of the structure in a level position. The vertical slide is arranged to receive curved blades, and the bed plate, to which the lower blade is attached, is capable of ready removal, to receive a curved bed plate with a shear blade bent to match the curve of the upper blade.

Strains. **Curved blades.**

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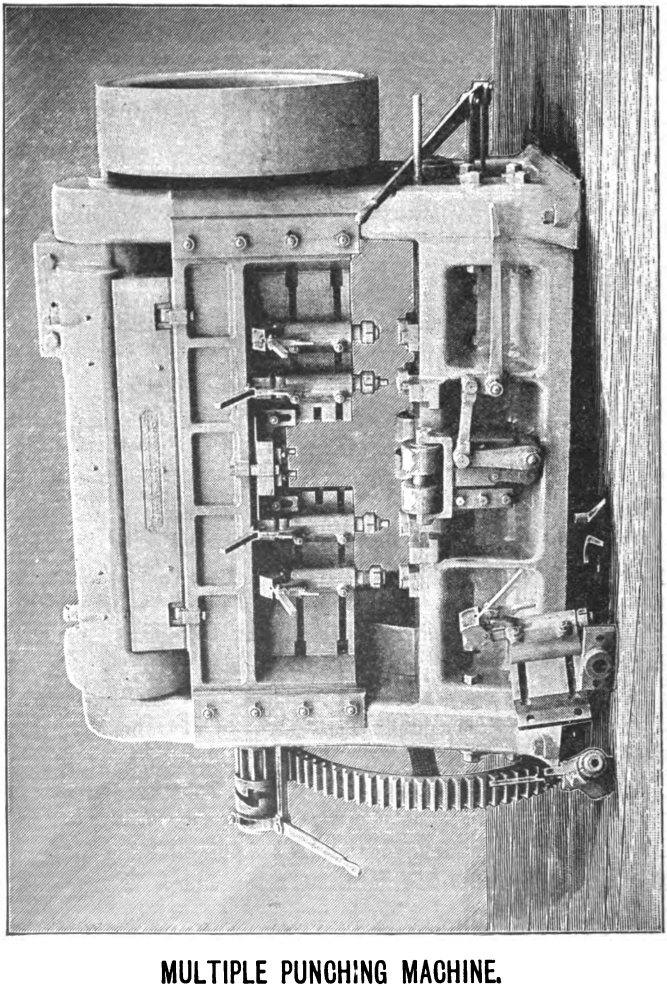
FIG. 81.



MULTIPLE PUNCHING MACHINE.

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MULTIPLE PUNCHING MACHINE.

Arranged with a cross-head working in slides between two housings, the sliding cross-head being operated by a long cam extending the full length of the cross-head and driven at one side by lever from a cam on the driving shaft. Width between uprights sufficient for sheets 5 feet 11 inches wide to be passed and be punched on the edges or across the sheet at any point of its length. Can punch sheets as wide as given or two narrower sheets at the same time. Will punch at one operation four angles or two channels. The driving pulley on the machine is 42 inches diameter and 12 inches face. This pulley should make 120 revolutions per minute. With the machine we furnish

Twelve Cylindrical Punch Holders.

Six Side Punch Holders, arranged to work the same as the cylindrical holders, without gearing.

Four Punching Holders, adapted to punching angles.

Apparatus for holding channels and beams, when being punched, consisting of supporting blocks, die holders, and grips 6-inch, 8-inch, 10-inch, and 12-inch sizes.

Four Die Blocks, with holes to one side for angles.

Twelve Die Blocks, with holes central.

One Stripper Bar, for plates.

One set of Angle Strippers.

One set of Blocks for holding adjusting-spring to angle stripper.

Two Angle Grippers.

Three Plate Grippers.

One Spacing Carriage, arranged to space to any multiple of ¼ inch up to 13½ inches.

One Guide Carriage.

Fourteen stands, with rollers complete.

124 feet of geared and 124 feet of plain rack, making a traverse of spacing and guide carriage, each of 59 feet.

One Blocking piece.

Two Stands, without rollers.

THE introduction of this very important tool into works fitted for bridge construction marks an important step in progress. Its use enables work to be punched with great accuracy, and insures

Insures accurate spacing.

the possible assemblage of the parts of beam work without any use of the drift or reamer. It is fitted with a heavy cross-head working from a lever and cam, which cross-head is long enough to carry 15 punch holders placed 4 inches from centre to centre. Throw-out mechanism to each punch holder, so that such ones only can be used at a time as is required by the work to be punched. Special right- and left-hand punch holders may also be used, bringing the punches much closer together than 4 inches. The machine will take in, clear of the working lever, plates 5 feet 11 inches wide, and such plates, while being passed through the machine, can have holes punched in continuous rows along the entire sheet at edges or at any part; also at intervals, rows of holes can be punched across the sheet, such punches being only limited in number by the strength of the machine, the number varying with the size of the holes to be punched. There is in the centre of the cross-head of the machine a gap, filled by a block when the machine is used as a Plate Punch, but which block is removed when channels and angles are to be punched, adapting the machine to receive such work to great advantage. Special devices are arranged to receive two channels at the same time, or to carry four angles and punch them at the same time. Thus sheets are punched with the spacing device and then the other members, of say a plate girder, are punched with the same spacing device, as also any pieces to form the top and bottom chords of the beam. This arrangement insures the greatest accuracy of punching, and enables the work to be assembled with a certainty that the rivet-holes will all agree, and the whole operation is performed with certainty and dis-

Punches.

Capacity of the machine.

Gap for channel bar punching.

All parts of one plate girder punched with same spacing device.

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patch. The various devices accompanying the machine to enable it to perform this work on the many sizes of channels, angles, and the like are enumerated in the specification at the head of this article. The spacing carriage is peculiar. It has a spacing device which can with great readiness be set to any required distance, in quarters of an inch, from ¼ inch to 13½ inches, inclusive, at one stroke. There are rails and rack furnished for one side of the machine, and plain rails for a trailing carriage on the other side of the machine, with rollers at intervals to sustain the weight of the work being passed through. The spacing carriage is provided with gripping tongs to hold the various pieces it is capable of passing through at one time, as is also the trailing carriage. The machine proper is provided with strippers and clamping devices for the work, such as channels and the like, as enumerated in schedule, and there are lifting rollers to raise the work from the dies so as to clear the fins resulting from the punching and to enable the spacing device to work freely.

Spacing carriage.

Gripping tongs.

Clamping device.

CHANNEL BAR PUNCH.

We make a lever machine somewhat similar to our other lever machines, which is adapted to punching channels, angles, and narrow plates. This machine is fitted with the spacing carriage used with the multiple punch, and will do for the same kind of work, with the exception of wide plates. We illustrate this tool on page 230.

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LEVER PUNCHING MACHINE.

Operated by a heavy wrought iron lever within the housing. Independent stop motion by means of a four-toothed clutch in the housing. Punch rests up when clutch is out of gear. Vertical motion of slide $1\frac{1}{2}$ inches. Can be used to punch 2-inch holes in plates of iron $\frac{1}{2}$ inch thick. Fast and loose pulleys on the machine 36 inches diameter, 7 inches face, which should make 114 revolutions per minute.

We make two sizes of this machine, namely:

Punch, with 26 inches over-reach, to punch holes in the middle plates 52 inches wide. Will punch boiler rivet holes 29 inches from edge of plate.

Punch, with 33 inches over-reach, to punch holes in the middle plates 66 inches wide. Will punch boiler rivet holes 36 inches from edge of plate.

FOR remarks on the theory of the operation of these machines, see page 202. The heavy wrought iron lever in the housing raises the punch by its gravity, and the cam which moves the lever is so shaped as to cause the motion of the punch in operating to be at a uniform rate of speed; returning quickly, it dwells for some time at the top of its stroke, thus giving ample time to shift the plate for the next hole.

Motion of punch uniform.

Stopping by means of clutch.

We keep the cam in position under the lever, and attach it to or detach it from the shaft by means of a four-toothed clutch, which while it can only be withdrawn at the completion of the stroke, yet at the same time it will permit the starting again to be effected in any one of four positions of the driving wheel in relation to the cam, thus saving much time, and also preventing the damage to the machine likely to arise from working the cam only partly under the lever.

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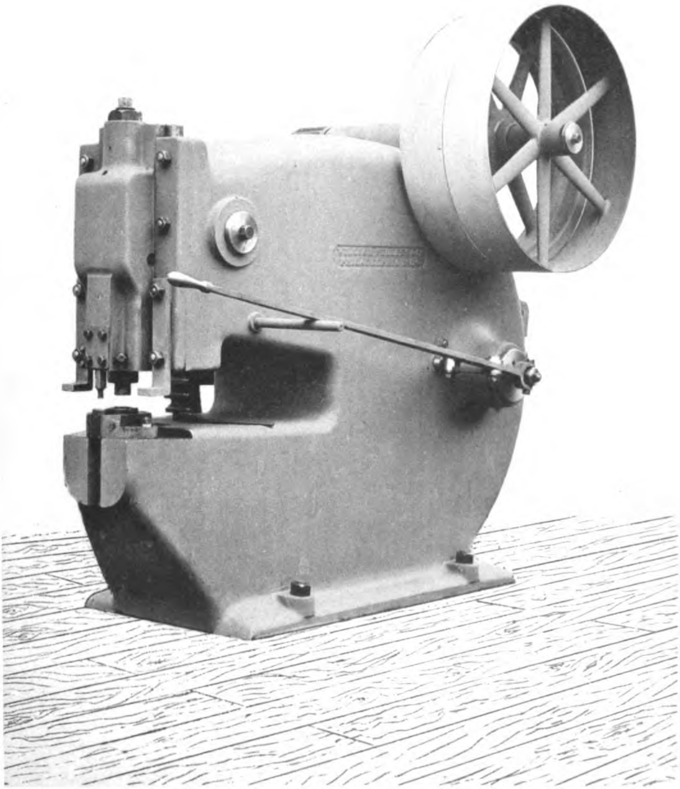
Fig. 82.



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PUNCHING MACHINE, 26 INCHES OVERREACH.

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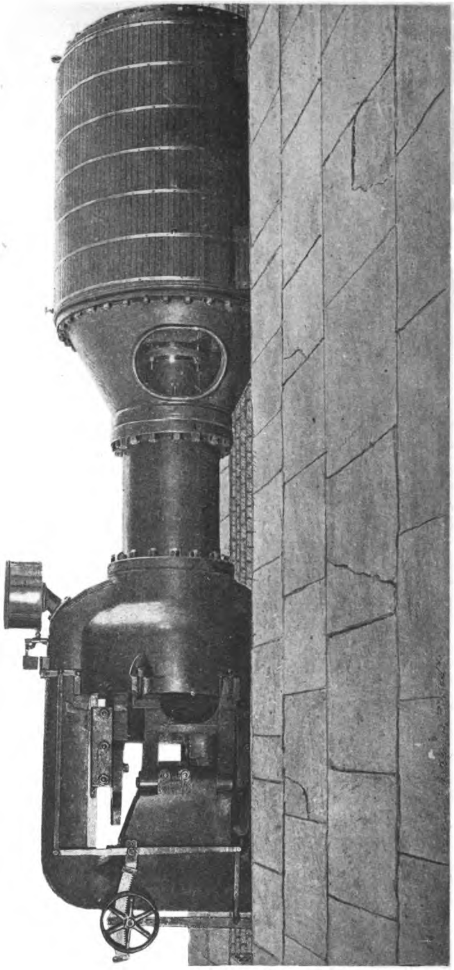
FIG. 82A.



BLOOM SHEAR.

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BLOOM SHEAR.

FOR CUTTING $7\frac{1}{2} \times 7\frac{1}{2}$ INCH HOT STEEL INGOTS.

Operated by a direct acting steam cylinder transmitting its power to a hydraulic cylinder and making a stroke of the cutting blade to each stroke of the steam piston. The hand lever, which is moved by the operator, controls the movement of the steam piston. The motion of the piston, and of the blade, follows the motion of the hand lever, stopping when it stops and moving back or forward as the lever is moved in either direction. An entire cut or a partial one can be made at the will of the operator. Stalling the machine by attempting to cut too cold a billet does not produce any injurious strain on the machinery. Is designed to do its full work with 70 pounds steam pressure.

Shears hot metal.

THIS machine, as shown, has been designed to cut hot steel blooms or ingots, and is *not to be used in shearing cold metal.* It has a stroke of $8\frac{1}{2}$ inches, and is operated by hydraulic power, the water being forced into the hydraulic cylinder by means of a large steam cylinder and a direct acting pump of such capacity, that one stroke of the steam cylinder completes one stroke of the hydraulic cylinder and of the blade. The motion of the piston in the steam cylinder is so controlled by the valve motion that the cut can be made or the blade drawn back by means of the working lever as readily as if it was moved by the hand of the operator directly. Both the forward motion of the cutting blade and the retraction of the same are in direct ratio to the speed or motion of the steam piston, and the cut in hot steel is without shock to the machine. It is not advisable to use the machine for cutting cold metal on account of the sudden driving forward of the blade at the moment of the part-

Valve motion.

Blades move in ratio to steam piston.

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ing of the metal from the expansion of the steam in the cylinder. The blades that do well in cutting hot metal are ill fitted to stand the pressure of cutting cold metal, and the inability of the machine to cut cold, is amply compensated for by its facility of operation in cutting large masses of hot metal without any danger of injury to the machinery from stalling. Leak from the hydraulic cylinder is compensated for by a recharging device, which insures the water cylinder being at all times full, if a supply of water be maintained in the feeding tank. All packings are arranged to be easy of access for repair, and the machine does not require any particular skill on the part of the workman operating it. Its strength is predicated on a maximum pressure in the cylinder of 70 pounds per square inch, but much less pressure than this will do the maximum work if the metal be hot.

Stalling does not hurt the machine.

If the machine is required for use on cold as well as on hot metal, we can make provision for such use by an attachment that will prevent shock when the metal parts, but such attachment increases the cost of the machine.

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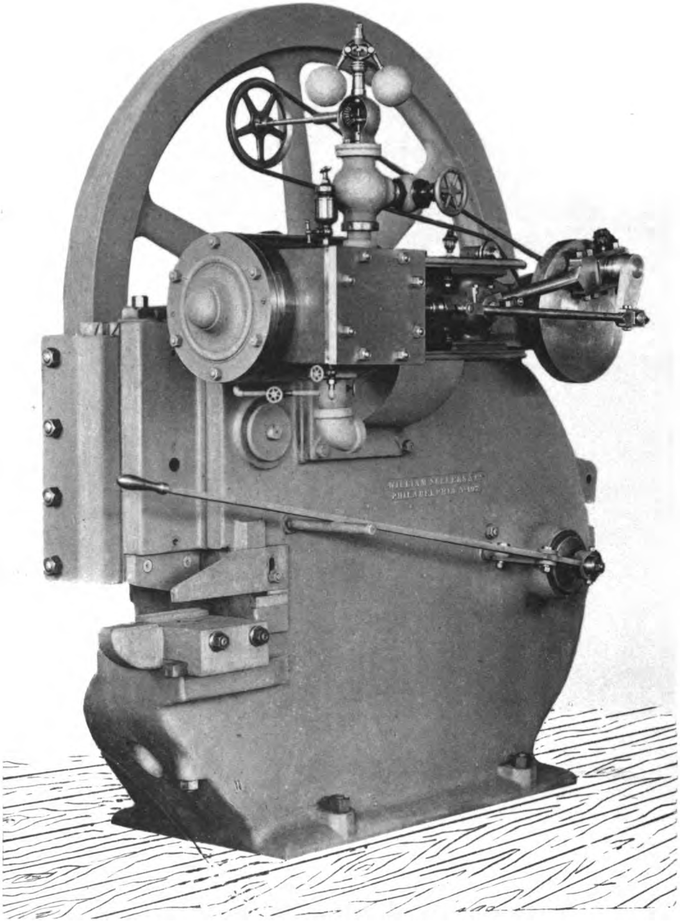
FIG. 83.



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BAR SHEARING MACHINE.

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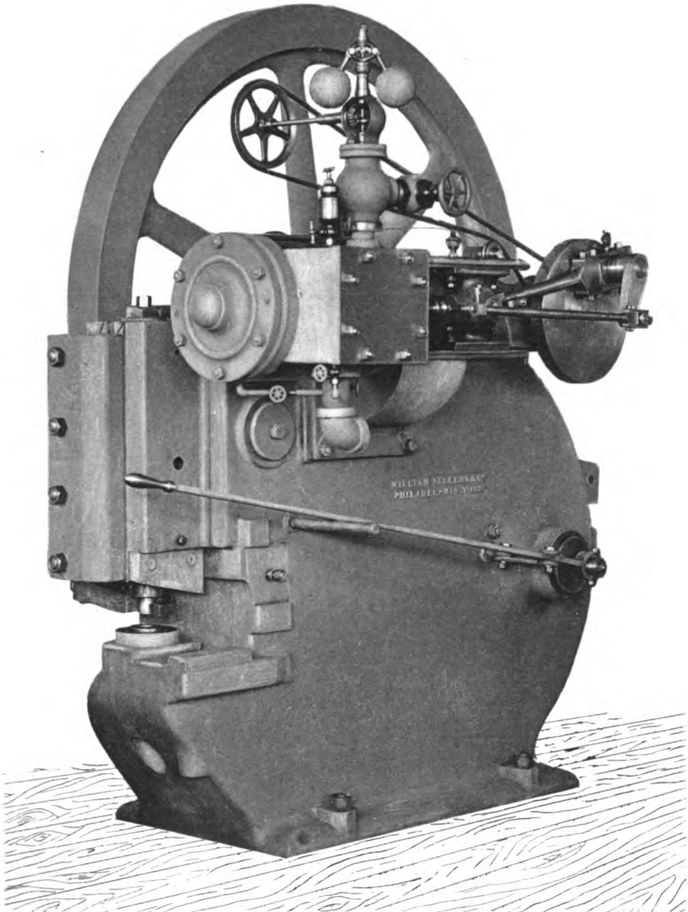
FIG. 83A.



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BAR SHEARING MACHINE—WITH PUNCHING ATTACHMENT.

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BAR PUNCHING MACHINE FOR 1½ INCH PLATES.

Operated by heavy wrought iron lever within the housing. Independent stop motion by means of a four-toothed clutch in the housing. Blades rest open when the clutch is out of gear. One pulley only on the machine, 42 inches diameter, 12 inches face, making 120 revolutions per minute. The belt should be double. Has 6-feet fly-wheel in addition to pulley.

THIS tool is admirably adapted for plate work in car shops, and is the mate to a shearing machine, see page 208, which is for iron of the same thickness, and these machines cover much of work on draw irons and the like. It is usual to place these machines near to the main line and drive direct without any counter-shaft, as the blades can be stopped by the clutch in the machine. For repairs, it is simpler to throw off the belt than to provide any means of stopping the belt. This and similar shearing machines or punching machines can be operated by an engine attached to the machine, when such application is desirable. The manner of attaching the engine is shown on page 227.

No counter-shaft.

Engine attached when required.

The various machines described in the foregoing pages for punching and shearing do not cover all the combinations or changes that can be made to meet the requirements of the two operations, viz., punching and shearing. The form of the housings of our machines enables us to introduce many modifications to meet any special cases that may be presented. The great power and stiffness of the machines make them very well fitted for punching fish plates where four holes are to be made at one stroke. The utmost care has been taken in designing these machines to insure their durability and economy in working.

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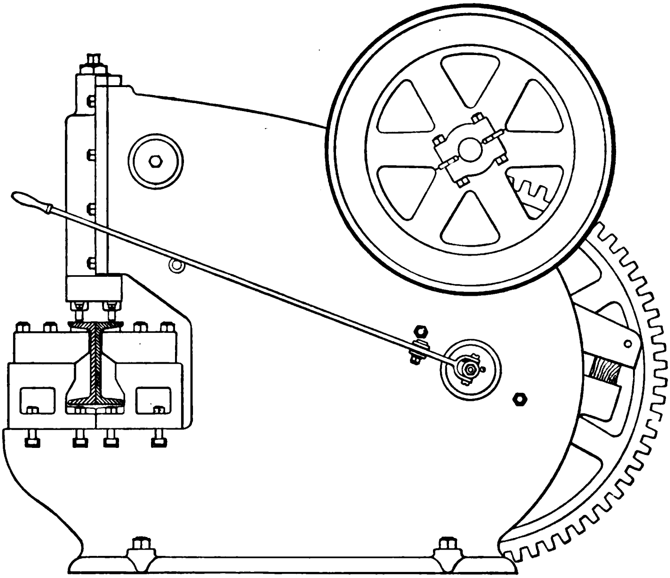
FIG. 84.



CHANNEL BAR PUNCH.

THIS machine, mentioned in connection with our multiple punching machine, on page 221, is fitted with the same spacing device as is described on the same page, and with it we furnish a number of the special devices mentioned on page 219. While it will not do the work on wide plates that is accomplished by the larger machine, yet it will, in the same manner, punch the channels, angles, and narrow plates used in bridge construction in a very satisfactory manner.

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STEAM HAMMERS.

(*For Report of Judges, see page* xiii.)

SIZES.

Size or Weight of Hammer Ram.	Length of Stroke.	Height under Frame.	Width between Frames.	Hammer Face.
300 lb.	15½″	Single Upright.	Single Upright.	6¾″ × 4½″
650 "	18″			8½″ × 5½″
1000 "	20″			9″ × 5¾″
1500 "	23″			10¼″ × 6″
2000 "	27″			11¾″ × 7″
2500 "	31″			13½″ × 9″
1¾ ton.	3′ 2″	6′ 10″	7′ 6″	16½″ × 10″
2¼ "	3′ 6″	7′ 3¾″	8′ ½″	17¾″ × 11″
3 "	3′ 11½″	7′ 10¼″	9′ 2″	19½″ × 12″
4 "	4′ 6½″	8′ 5½″	9′ 8¼″	21¼″ × 13″
5 "	5′	9′ ½″	11′ 3″	22½″ × 14″
6 "	5′ 6″	9′ 8″	12′ 6″	24″ × 14¼″
8 "	6′ 3½″	10′ 8¼″	13′ 8″	26″ × 16″
10 "	7′	11′ 9″	14′ 8″	29½″ × 18″

GENERAL SPECIFICATION.

Piston rod or hammer bar of solid wrought iron, passing through both heads of cylinder; piston head forged solid with piston rod. Hammer head adjustable on lower end of bar; bar prevented from turning by upper cylinder head. Slide valve balanced.

Hammers of 2500 lbs. weight and under have one upright only, are double acting, taking steam above and below the piston, with self-acting valve gear and hand motion operated by the same lever; can be changed at will whilst in operation, thus affording complete control over the length, rapidity, and force of blow; also, enabling

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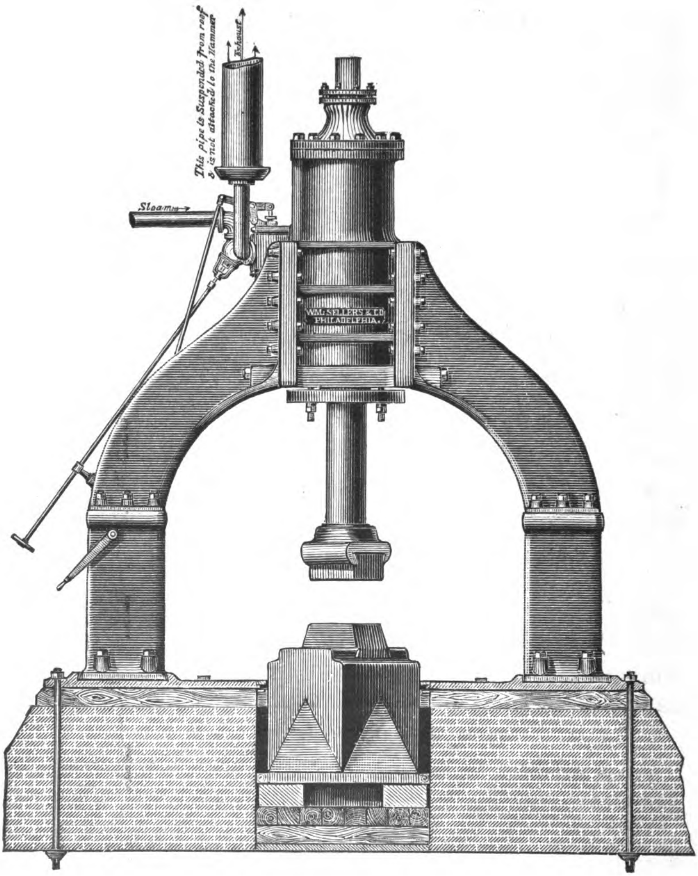
FIG. 85.



DOUBLE UPRIGHT STEAM HAMMER.

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the hammer to be used as a vise or squeezer. 1000 lbs. and under have anvil block passing through the base of upright. Hammers of 1500 lbs. and under are provided with a means of throttling the exhaust below the piston, so as to enable the blow to be diminished in intensity without materially decreasing the rapidity of motion. This attachment is of the utmost importance in finishing light work or tilting steel. All hammers over 2500 lbs. weight have double uprights and are hand-working only, taking steam above and below the piston, thereby increasing the force and rapidity of blows.

IN our introduction into this country of the "Morrison Steam Hammer" we were influenced by what seemed, in our judgment, the practical advantages of his system over all others then known. During the many years we have been making these machines, our attention has been constantly directed towards improving the mode of construction and increasing their durability and efficiency. The essential peculiarities of Mr. Morrison's system were in making the part which strikes the blow—that is, the hammer —of one long bar of wrought iron, having the piston welded to and forming part thereof, and guiding this bar by the top and bottom cylinder heads only, thus doing away with the usual side guides in the hammer frame, leaving the entire space below the cylinder free for the use of the workman in handling his work, whilst the hammer head and die are guided more efficiently than in any other system, and the frames are subjected to less strain.

Solid bar.

No side guides.

These hammers, as first constructed, had a uniform diameter of bar above and below the piston, with an enlargement at the lower end, in which enlarged part the dovetail for holding the dies was planed. The upper end of the bar—*i.e.* the part above the piston —was planed flat on one side, to keep the bar from turning. In practice, it was found that hammers

Flat on top end of bar.

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made with this uniform diameter of bar and solid hammer head would in time give out immediately above the enlarged part of the bar at the lower end, because this is the place where the accumulated concussive force is intensified, resulting in some instances in fracture.

Liability to break.

Proceeding on the theoretical idea that in a bar of iron used as a battering ram, the mass of metal forming the ram should increase in sectional area towards the point of impact, we have been led to make the diameter of the piston rod or ram greater below the piston than above it, thus bringing the greatest mass of metal nearest the point of impact, and proportioning the parts so as to be better able to withstand the strain incident to each part.

Increase of bar below piston.

This change, while it made a very decided improvement in the durability of the bar, rendered possible a more important change,—viz., the attaching a loose hammer head, of the requisite size, to the lower cylindrical end of the hammer bar, by means of a circular taper key. Fastening the hammer head by means of this circular key has entirely done away with the possibility of breaking the bar by concussion. As now arranged, the force expends itself at the extreme end of the ram, in contact with the die face, and produces no other result than is attainable by hammering on this part,—*i.e.* on a surface great enough not to be burred up.

Loose hammer head.

Increased durability.

This system of loose head insures the durability of the hammer bar, it also permits the setting of the dovetail in any required position in regard to the anvil block, and admits of a ready repair of the part which holds the top die, if injured by careless driving of keys, etc. In reference to the keys used in holding dies, it will be found that each machine sent out from our

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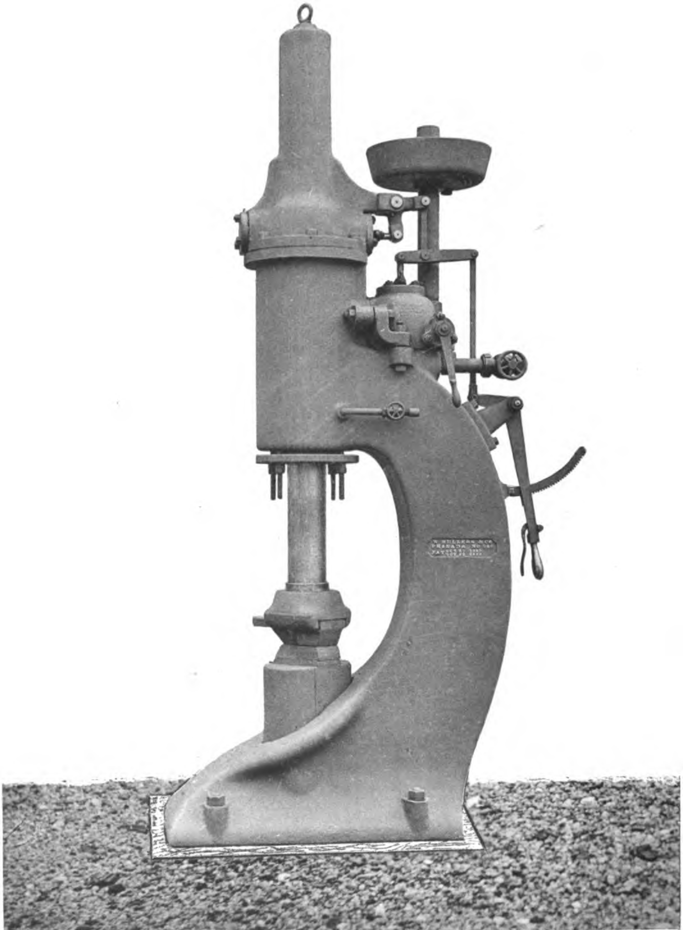
Fig. 86.



Phototype, F. Gutekunst, Philada.

300 LBS. STEAM HAMMER.

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works has its die held by means of a crimped steel key, which is of uniform thickness (not made taper), and which holds the die with an elastic pressure. We recommend the use of this form of key in preference to any other, care being taken to re-bend when they become loose by use.

Use of crimped key.

SINGLE UPRIGHT STEAM HAMMERS.

Our steam hammers, with single upright and overhanging cylinder, are all provided with automatic valve gear. We rate these hammers by the weight of the hammer bar in pounds, not in tons. They range in size from 300 pounds up to 2500 pounds.

In our automatic hammers the motion to work the valve has been obtained from a diagonal groove in the upper end of the hammer bar. In early practice this diagonal groove was planed in the flat surface, which surface Mr. Morrison adopted as a means of preventing the bar from turning; but as this slot so made was found to cause a slight tendency to rotate the bar back and forth, it has been abandoned, and inclined grooves, diametrically opposite to each other, are made to work a brass yoke, whose line of vibration is through the central axis of the bar, thus entirely obviating the above objection, and very much increasing the extent of wearing surface, and permitting the guiding of the bar by brass keys in these opposite grooves. The simplicity of the valve motion in all our recent steam hammers recommends its use. Apart from this, we have modified the ports in the steam chest, so as to use a supplemental valve to throttle the exhaust below the piston, without impeding the free exhaust above the piston. This enables the hammer to strike quick, light blows for finishing; in other words, the hammer

Diagonal groove.

Inclined grooves.

Valve motion.

Choking exhaust below piston.

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Light quick blows.

can go up as quickly, but in coming down its force may be gauged by the steam cushion upon which it descends, which steam, thus condensed in bulk, re-expands in the up stroke, to the manifest economy of steam used. To fully appreciate the importance of this improvement it must be borne in mind that any attempt to gauge the intensity of the blow by throttling the ingress of steam to the cylinder, slows down its speed and renders its automatic blows irregular without proportionately decreasing their force, as in many cases the weight of the bar alone is too great for the character of work in progress. We cannot too strongly recommend this device, which is placed upon all hammers of 2500 lbs. weight and under, such hammers being more often required to do both light and heavy work than the larger sizes.

In explanation of the efficiency of the valve motion as used by us, it must be borne in mind that the easy sliding balanced valve, obtaining its motion from the hammer bar, as above shown, is readily shifted upon the ports by the working lever and the length of stroke varied at will by the operator. In addition to this, if the working lever be moved by hand, in such a manner as to accord in time with the automatic stroke, the force of the blow is intensified to the extent of following the hammer bar down to the work with a full port open below for exhaust, and a full port for ingress of steam open above; in other words, the full force of the steam acts down through the entire stroke, adding to the weight of the bar the force of the steam, at whatever pressure it may be carried, acting over the whole piston area. It must be manifest to the most casual observer that the hammer bar as used in these hammers, in one solid mass of wrought

Balanced valve.

Hand lever.

Steam on top of piston.

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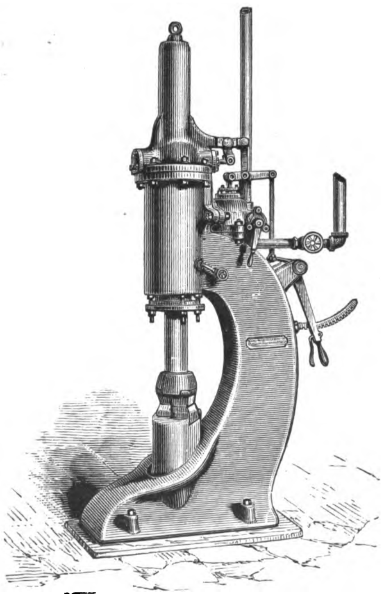
iron, must be better adapted to the use of this steam force, to drive it down, than are those hammers in which a cast iron "tup," or hammer head, sliding in side guides, is raised by means of a piston rod and piston attached to its upper end, and in which the down pressure of steam can only be exerted through the comparatively small diameter of piston rod.

A slow motion of the working lever will permit a corresponding slow raising of the hammer and its slow descent, with a squeezing force upon the work, so that it permits its advantageous use as a squeezer for bending and holding work between the dies. In short, the valve motion with the one working lever enables the workman to have as perfect control of the rapidity, force, and character of the blow as is possible with a hammer held in his hand and controlled by his will. Hammers up to and including 2500 pounds weight of ram are made with one upright only; those of 1000 pounds and under are so made as to inclose in their base the top of the anvil block, which block rests on a separate foundation, and thus relieves the frame from shock.

Fig. 87.



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DOUBLE UPRIGHT STEAM HAMMERS.

All of our steam hammers over 2500 pounds weight of hammer bar are rated by their weight of hammer bar expressed in tons of 2000 pounds, the smallest size being 1¾ tons weight. These are all made with double uprights, spread wide apart, affording ample room for easy manipulation on the part of the workman. The cylinder is securely bolted between these uprights, which, from their peculiar form, act as efficient braces to hold the cylinder firmly in position. The valve chest is placed on the side of cylinder, allowing the crane to swing up close to it, without any possibility of striking the valve gear. The working boy stands upon the floor level, not on a raised platform, thus enabling him to more certainly gauge the height of blow. In these double upright hammers the valve motion is not automatic, it having been found that hand-working hammers are more convenient for the use to which they are applied. The uprights of the hammers are each made in two parts, the division being at the top of the straight portion of upright, where the arch to the cylinder springs from, and between these parts we interpose an elastic medium. The uprights are bolted to extended foundation plates, these plates in turn resting on and being secured to the foundations, with an intervening layer of timber to give more elasticity. The anvil block rests on a separate foundation, with layers of wood under it for the same purpose. In reference to weight of anvil block, it is usual to make its weight, when used for hammering iron only, about five times the nominal weight of hammer; thus, for a 2-ton hammer, the anvil block should not weigh less than ten tons; but,

Valve chest back of cylinder.

By hand only.

Foundation plates.

Anvil.

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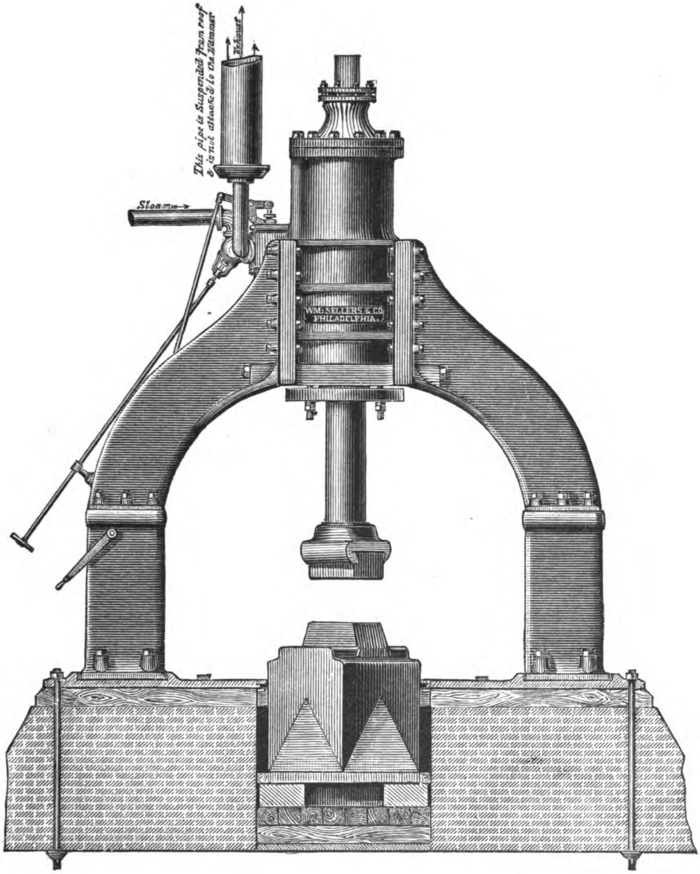
FIG. 88.



DOUBLE UPRIGHT STEAM HAMMER.

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when used for hammering steel, it has been found advantageous to make the anvil block heavier,—say from eight to ten times the weight of the hammer. It is not essential that this extra weight be obtained in one solid block; it is as well to add weight by placing under the regular anvil block a wide-spreading under plate of the requisite additional weight.

Nominal weight.

In speaking of the nominal weight of these hammers, it must be borne in mind that we rate our hammers by the actual weight of the hammer bar, not by the force of the blow. It is necessary to note this, inasmuch as some makers rate their hammers by some assumed force of blow they are presumed to be capable of striking. Thus, our $1\frac{3}{4}$-ton hammer has a hammer bar weighing $1\frac{3}{4}$ tons. We do not indicate what its force of blow is,—such force being dependent upon many considerations, such as thickness of work being acted on, softness of material, and pressure of steam. We emphasize this, because this difference in mode of rating leads to wrong conclusions on the part of inquirers, who may think the price of our $1\frac{3}{4}$-ton hammer high, as compared to the price of some other makers' $1\frac{3}{4}$-ton hammer, which, in point of fact, may be a 300-pound hammer, striking, it is assumed, a $1\frac{3}{4}$-ton blow.

Steel hammer bar.

When hammers are to be used on very heavy or severe work, such as involved in some of the ingot chipping, etc., in Bessemer works, we recommend a steel hammer bar in place of the wrought iron one. When we furnish the steel bar, the piston is then not made in one piece with the bar, but it is attached to it in so secure a manner as to entirely preclude a possibility of it shifting in use.

Many of our hammers have been furnished with a

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dome or cap over the upper end of the hammer bar, this dome being part of the top cylinder head, the intention of the dome being to do away with any packing about the upper end of bar and to permit the steam to act over the entire area of the piston on the down stroke. But as these domes have sometimes broken loose from the head from the vibrations of the frame, we now make all our double upright hammers without this dome, providing a stuffing box at the upper cylinder head and allowing the bar to project through and be seen above the cylinder. We find this gives entire satisfaction; and in this connection it may be well to note that in some cases of special work we have made our single upright hammers hand acting only, and with the bar projecting through the top cylinder head in the manner just stated.

No dome to top head.

Small hammers hand acting.

We would call attention to some of the very important improvements we have made, which, while mentioned in the foregoing pages, should yet be dwelt on. We have very much improved the method of securing the frames or upright to the cylinder. We pass steel bolts through from frame to frame at the lower end of the cylinder, and we arrange these bolts so as to have a free circulation of air about them to diminish their elongation from heat. We make the casting of the frames near to the cylinder with very stiff braces where the bolts take hold. The frame or upright on each side of the cylinder is now made in two parts, the division being made at or near to the point where there is the need of the most elasticity, and between the upper and lower ends of the uprights we interpose layers of wood to permit some motion under the strains coming from foul blows. This construction diminishes the cost of repairs. The frame

Securing frames to the cylinder.

Upright in two parts.

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Upright in box form.

is now made in box form in place of ribs and web of the I beam type. The valve chest is placed to one side of the cylinder, directly over one of the uprights.

Cranes.

This permits cranes to swing up to the cylinder on either side of the hammer. All steam hammers are submitted to severe strains, some of which cause violent side vibration, and it is to provide against the danger arising from these strains that we have instituted experiments which have led to our recent improvements. It is very important to insure a free

Exhaust pipe.

escape for the exhaust steam. Long exhaust pipes, passing up through the roof of the building and attached to the hammer, are submitted to great strain from the shaking of the hammer and tend to choke the

Collin's Patent exhaust.

exhaust. We furnish all our hammers with Collin's Patent exhaust. In this system the exhaust passage terminates close to the steam-valve and passes into a larger pipe dependent from the roof, but in no way connected with the hammer, the condensed water flowing back in the large pipe or thrown out of the cylinder at the starting of the hammer falls into a pan attached to and near the end of the exhaust pipe or nozzle of the hammer and from thence is carried off by drain pipe.

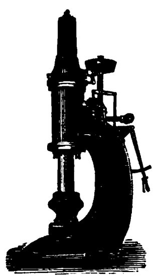

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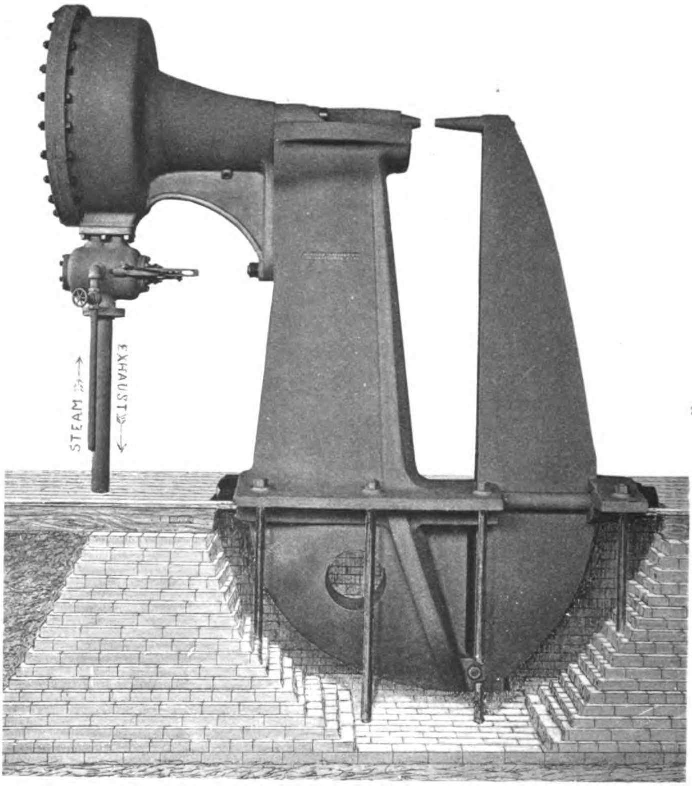
Fig. 89.



Phototype. F. Gutekunst. Philadelphia

STEAM RIVETING MACHINE, 72-INCH OVERREACH.

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PATENT STEAM RIVETING MACHINE.

Operated by the direct action of steam, yielding a steady pressure and not driving the rivet with a blow. Cylinder separate from the main upright and so attached as to permit the substitution of hydraulic cylinder for the steam, if it is desired to change to the hydraulic system. Steam valve accurately balanced and so made as to effect the drawing back of the riveting die by the charge of steam which has been used to do the riveting. Riveting stake of best forged iron securely fitted to the main upright, and of such shape as will permit the driving of rivets in corners of square fire-boxes; the cylinder being far enough from the riveting stake to permit the driving of the rivets which fasten the waist of locomotive boilers to the fire-box. Riveting die so placed as to permit the ready insertion of the hot rivet without having to swing the boiler around for that purpose. Tension of steam required to drive ¾-inch rivets 60 pounds per square inch.

We make two sizes of these machines.

72-inch steam riveting machine will take in cylinder 27 inches diameter, driving the rivets 72 inches from the end.

60-inch steam riveter will take in sheets 60 inches wide from the rivet seam to the end of cylinders 25 inches in diameter.

To either of these machines we attach, when ordered, a supplementary riveting stake, which will permit smaller flues to be riveted without the removal of the main stake.

RIVETING MACHINES.

SINCE our first publications on the subject of power riveting, issued during the year 1874, we have made very important improvements in both the steam and hydraulic systems as carried out by us.

Tweddell's riveting machine.

As manufacturers in the United States of Mr. Ralph H. Tweddell's various Hydraulic Machines for riveting, so extensively used in England, we have largely increased the applications of his invention as well as improved the machines.

Improvements in steam riveting machines.

The improvements in our steam riveting machines have been in the direction of greater strength and

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increased durability, and the application of the best features of the hydraulic system to the steam system. That is to say, we now make the steam riveters do their work by pressure, and not by impact or blow. Where the boiler pressure can be varied to suit the size of the rivets being driven, and can be maintained at a uniform pressure during the entire work, the steam riveter will be in all respects as effective as the hydraulic in stationary machines.

Boiler pressure must be uniform.

Attractive features of hydraulic machines.

The attractive feature of the hydraulic system is, that the pressure to be applied in each case is gauged at the accumulator by an adjustment of the weights, which determine the pressure per square inch on the ram of the machine. If the water be admitted to the machine from the accumulator slowly, the pressure on the ram will be that in the accumulator as determined by the weights, and if the valve is opened quickly, so as to admit a very free flow of water and a consequent rapid fall of the accumulator, there may be an increase of the pressure over that due to the weight from the impetus of the falling load on the accumulator, but not amounting to any injurious increase.

Gives uniform pressure per square inch.

Hydraulic machines lighter.

The very much higher pressure per square inch at which hydraulic machines are run, as compared to either steam or pneumatic machines, makes the cylinder smaller, and consequently the machines are less cumbersome with equal power, a matter of very great importance with portable riveting machines, and of some moment in many kinds of stationary riveting machines.

Can be driven by belt.

The hydraulic riveting machine can be used wherever power by belt is obtainable, and the pumps and accumulator may be placed at any point most convenient for the application of the power, their distance

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from the riveting machine involving no serious loss in efficiency.

Our very extended experience with the hydraulic riveting machine system in its various forms has led us to make alterations in the steam system of riveting to bring it to the same standard of excellence. So long as it was believed that blows were needed to do good riveting by power, the improvements in the machines were in the direction of making them stronger and better able to withstand the severe shocks which sooner or later break down all such structures. Hydraulic riveting demonstrated not only that the work could be as well done without a blow, but that it could be *better done without a blow*, and that the riveted material was stronger when so secured than when subjected to the more severe treatment under impact. Many experiments with steam riveting machines led to the adoption of a system of very small steam-pipe connections from the boiler to the riveter, coupled with an increase in the diameter of the riveting cylinder and the use of a very large valve on the machine to permit a free flow of steam in exhausting and effecting the draw-back with the charge used in driving the rivet. This improvement has brought our steam riveting plant up to the best condition of hydraulic riveting, so far as stationary machines are concerned, with the one single exception that the regularity of the steam pressure is still left to the discretion of the persons employed in doing the work. When a separate boiler is employed to run the riveter no great trouble is found in a close regulation of the steam, and the steam riveting system is very satisfactory.

Steam riveters as improved.

Riveting better done by pressure than by blows.

Controlling the motion of steam riveters.

Boiler pressure.

It was in reference to the use of one of these machines that Mr. W. S. Hudson, who was for so many

Mr. Hudson's experiments.

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years the Superintendent of the Rogers Locomotive Works, at Paterson, N. J., said, a short time before his death, that he had for a long period of time kept records of the number of rivets driven by the hand-driving gang, and also by the gang at the steam riveting machine, in both cases making no allowances of any kind for delays. The rivets driven per month by each was, for the hand-driven rivets, at the rate of 12 rivets per hour, and for the steam-driven rivets, 120 per hour. In the case of the hand-driven rivets the boiler remains stationary and the men move about it, while the steam-driven rivets require the whole boiler to be hoisted and moved about at the riveting machine to bring each hole to the position required for the dies. Notwithstanding the trouble involved in handling and moving the boiler, it is possible to do ten times as much work, and with less skilled labor, by the employment of the riveting machine.

Extra work done by power.

During the year 1872 the editor of the *Railroad Gazette*, published in New York, caused some experiments to be tried, with the view of showing the difference, if any, existing between hand and power driven rivets. His experiments were conducted at Paterson, N. J., the power riveting being done on one of our 56-inch Direct Acting Steam Riveting Machines. Subsequently, on August 3, 1872, an article on this subject came out in the *Gazette*, from which we extract the following:

Mr. Forney's experiments with hand and machine driven rivets.

"**DIRECT ACTING STEAM RIVETING MACHINES.**

60-inch machine.

"In presenting a full-page illustration of the steam riveting machine designed and built by Messrs. William Sellers & Co., of Philadelphia, we take occasion to make a few remarks on the principles in-

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volved and the practical use of such machines. What is manifestly required in perfect riveting is, that the metal of the rivet while hot and plastic shall be made to flow into all the irregularities of the rivet holes in the boiler sheets, that the surplus metal be formed into heads as large as need be, and that the pressure used to produce these results should not be in excess of what the metal forming the boiler shall be capable of resisting.

Flow of solids.

"It is well known that metals, when either cold or hot, if subjected to sufficient pressure, will obey almost exactly the same laws as fluids under similar conditions, and will flow into and fill all the crevices of the chamber or cavity in which they are contained. If, therefore, a hot rivet is inserted into the holes made in a boiler to receive it, and is then subjected to a sufficient pressure, it will fill every irregularity of the holes, and thus fulfill one of the conditions of perfect riveting. This result it is impossible to accomplish with perfection or certainty by ordinary hand riveting, in doing which the intermittent blows of an ordinary hammer are used to force the metal into the holes. With a direct-acting steam riveting machine, however, an absolutely certain and continuous pressure can be imparted to each rivet, so as to force the hot metal of the rivet into all the irregularities of the holes in the same way as a hydraulic ram will cause water to fill any cavity, however irregular. In order to test and also illustrate the relative advantages of machine and hand riveting, we have had two plates riveted together, the holes of which were purposely made so as not to match perfectly. These plates were then planed through the centre of the rivets, so as to expose a section of both the plates

Continuous pressure

Test.

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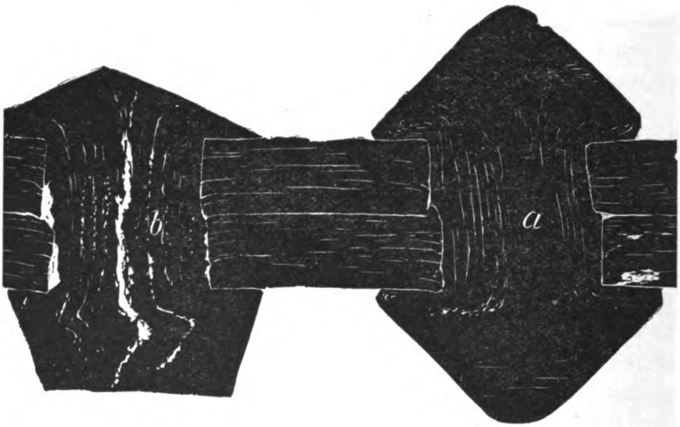
and rivets. From this an impression was taken with printer's ink on paper and then transferred to a wooden block, from which our engraving was made. *a* was put in by one of Messrs. Wm. Sellers & Co.'s

Fig. 90.



machines, and *b* by hand. It will be observed that the machine rivet fills the hole completely, while the hand rivet is very imperfect. The experiment was tried several times, with similar results each time.

Shorter rivets by hand.

"The hand rivets, it will be observed, fill up the holes very well immediately under the head formed by the hammer; but sufficient pressure could not be given to the metal—or at least it could not be transferred far enough—to affect the metal at some distance from the head. So great is this difficulty that in hand riveting much shorter rivets must be used, because it is impossible to work effectively so large a mass of metal with hammers as with a machine.

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The heads of the machine rivets are, therefore, larger and stronger, and will hold the plates together more firmly, than the smaller hand-riveted heads.

"Direct-acting steam riveting machines give a uniform force, if the steam pressure used be uniform, and they give such pressure as is needed, regardless in a measure of the amount of metal forming the rivet. These machines have been made on two general principles. In the English machines, a comparatively light piston of large diameter acting upon a not very large or heavy riveting ram is made to do its work by the pressure of steam alone.* In the machine illustrated, a very heavy piston and riveting ram are made to do the work by the combined effect of steam pressure and momentum. The ram and piston are of wrought iron in one solid forging, and weigh, when finished, over one ton. With the increased weight of the riveting ram a less diameter of steam cylinder is needed. Thus, it is said that one of these machines with a steam cylinder 31 inches in diameter working alongside of an English machine with a steam cylinder 36 inches in diameter does the same kind of work from the same steam boiler, and yet requires a shorter stroke, thus using less steam to accomplish the same result. In practice, it has been found that for locomotive boilers using $\frac{3}{4}$-inch rivets about 60 pounds pressure per square inch does the best work.

Weight of ram.

Pressure of steam.

"The machine illustrated is so arranged as to enable all the rivets about the ordinary locomotive boiler to

*** The English machine does not do its work without a blow. Its larger cylinder, though the ram is lighter, makes its work equally severe. In our recent machines we preclude the possibility of a blow being struck by contracting the size of the steam pipe, as has been explained on page 249.—W. S. & Co.**

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Drive all the rivets of locomotive boilers. be driven with ease; that is, it will rivet the corner seams of the fire box and drive the rows of rivets where the waist joins the outer shell of the fire box. **Method of using.** In the practical working of this machine it may be well to mention that the rivets are inserted from the outside of the boiler, not, as in hand riveting, from the inside. The boiler, suspended in slings attached to a crane, is drawn up to the riveting hammer, and the first blow struck carries the boiler, pushed by the rivet head, up to the post, and thus tends to close up the sheets as the head is being formed on the inside of the boiler. The second blow is then delivered with the boiler pressed up to the post or stake, and the steam pressure retained until the rivet has had time to cool. **Two blows to each rivet.** Thus two blows* are given to each rivet; and in this manner, allowing time for each rivet to cool under pressure, five rivets per minute can be driven. The **Valve.** arrangement of valve is such as to enable the charge of steam used in riveting to be utilized in its expansion to draw back the ram."

Number of men required. To drive rivets by hand, two strikers and one helper are needed in the gang, besides the boy who heats and passes the rivets; to drive each ⅝-inch rivet, an average of 250 blows of the hammer is needed, and the work is but imperfectly done. With steam riveting machine, two men handle the boiler, and one man works the machine; thus, with the same number of men as is required in riveting by hand, five rivets are driven each minute. The superior quality of the work done by

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* More recent practice has shown that blows are not required: the riveting is well done by pressure, the dies being held shut until the rivet cools. The effect of the blow is rather to stretch the seam, unless in case of too low steam being used to drive a large rivet.—W. S. & Co.

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the machine would alone make its use advantageous; but to this is added greatly increased amount of work done. On page 250 we give Mr. W. S. Hudson's experience with hand and power riveting. He makes the difference in favor of the riveting machine over hand riveting of at least ten to one. In setting up these machines, it is essential that they rest on good substantial foundations. We furnish with the riveter, when desired, the necessary over-head rigging of a crane, consisting of sheaves mounted in a carriage, with machinery for drawing the carriage back and forth on rails placed on beams over-head; and for hoisting purposes, we furnish a patent safety-crab, which, bolted to the foundation back of the machine, is operated either by hand or power, and is entirely under the control of the man who handles the valve of the riveter. The position and condition of the over-head rigging depend entirely on the character of the work done. When cylindrical work only is riveted, the ways upon which the over-head carriage rests may be in line with the axis of the riveting machine. If much straight-plate work is riveted, the ways should be placed crossways, or at right angles to the axis of machine, and a lateral motion should be given to the ways to adjust them in proper position in reference to centre of gravity of work being riveted and the position of the riveting stake. The riveting machine, as ordinarily constructed by us, is intended for locomotive work especially; but can as well do all the work on plain cylinder boilers, or on marine boilers. We also adapt, when required, a supplementary riveting stake of steel, upon which flues 10 inches diameter, and in length of 3 feet rings, may be riveted.

Foundations.

Crane attachment.

Safety-crab.

Will do all kinds of boiler riveting.

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STATIONARY HYDRAULIC RIVETER.

Operated by the direct action of water from an accumulator that yields a pressure per square inch adapted to the size of the rivet being driven; presses the rivet without a blow. Cylinder separate from the main upright, operating a sliding head, which carries the riveting die; this head so arranged as to permit a very ready adjustment of the length of the stroke, saving time and economizing the water used. The sliding head arranged to permit the ready driving of the hot rivet into the holes ready for the riveter without having to swing the boiler around for this purpose. Quick draw-back to the riveting die, and all the packings so made as to be of ready access for repairs. Valve of improved construction, with very few parts to get out of order. Riveting stake of best forged iron, and so made as to permit the driving of the corner rivets in square fire-boxes, and the hydraulic cylinder is so placed as to allow the rivets to be driven in the waist of locomotive boilers close to the fire-box.

We make two sizes of these riveting machines, corresponding with the same tools as made to be operated by steam direct, viz.:

72-inch stationary hydraulic riveter has an over-reach of 72 inches, and will rivet cylinders which are 27 inches in diameter with 72 inches over-reach.

60-inch stationary hydraulic riveter has an over-reach of 60 inches, and will rivet with this over-reach cylinders 25 inches in diameter.

To both these sizes of machine supplementary stakes can be attached, which will permit the riveting of smaller flues without the removal of the main riveting stake.

Cam driven riveting machine.

IN the earliest form of riveting machine, the riveting die was actuated either by a crank or a cam, so that the traverse of the die was uniform, and determined by this driving mechanism. The rivet, whether large or small, long or short, was compressed to the same length, often in rivet holes of varying diameters. Sometimes, therefore, the rivet did not fill the hole; sometimes the plates to be riveted were strained. The work was performed by gradual compression, in itself desirable, but the uniform traverse, operating upon irregular quantities in the rivet, and even forcing the metal into holes of varying capacity, failed to produce regular work.

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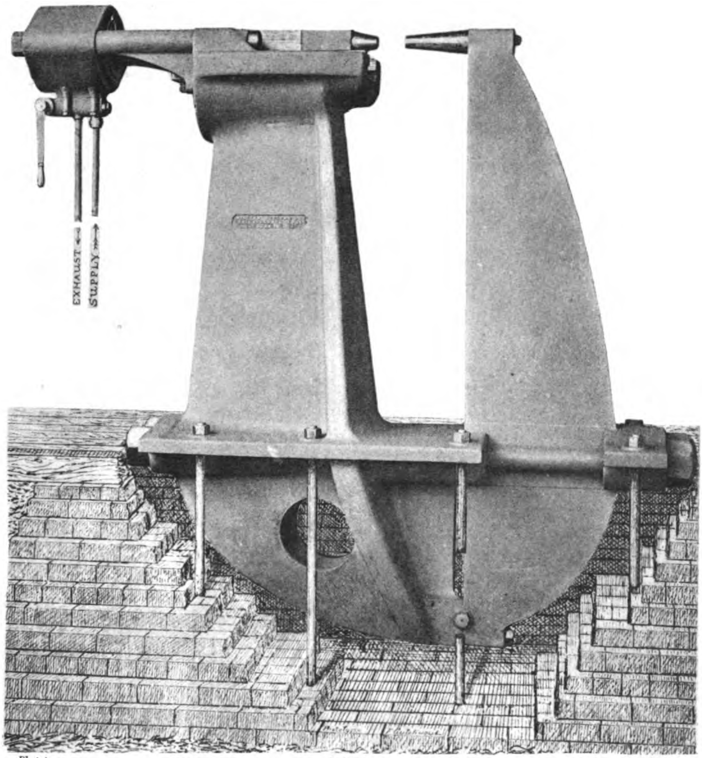
Fig. 91.



Phototype, F. Gutekunst, Philada.

STATIONARY HYDRAULIC RIVETER, 60 INCHES OVERREACH.

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Steam riveting machine.

The direct action steam riveting machine produces regular work with irregular quantities in the rivet or varying size of holes; but when on such machines the work is done by a blow, the shock is, in time, destructive to the machine, and sometimes is injurious to the work.

Hydraulic riveting without accumulator.

Hydraulic riveting was first accomplished by a machine on which hydraulic pressure was employed to act directly upon a compressing piston, which carried the riveting die; but in all these hydraulic machines, a pump was employed to produce the pressure in the compressing cylinder, which cylinder was in communication with the pump chamber through a valve which was opened by the fluid whenever the pressure in the pump chamber exceeded that in the cylinder; consequently the compressing piston, which carried the die, was moved only when the pump moved to force the fluid through the valve, and rested when the pump was taking water for its next stroke. Hence the die might be stationary, while a rivet was but partially headed. Moreover, the compressing piston and die did not move at the will of the operator, but with the motion of the pump, whether it was worked by hand or power. If by hand, the workman had no means of controlling the pressure but by his judgment or strength; if by power, a valve to release the pressure was provided, which could be opened by the operator whenever, in his judgment, a sufficient pressure had been exerted, but no means of determining this with any degree of accuracy was provided in either case, so that, although the pressure was gradual, and the traverse limited only by the performance of the work, the want of means to determine the latter produced irregular results.

Want of means to control pressure.

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The hydraulic riveting system combines all of the advantages and avoids all the difficulties which have characterized previous machine systems,—that is to say, the machine compresses without a blow, and with a uniform pressure at will; each rivet is driven with a single progressive movement, controlled at will. The pressure upon the rivet after it is driven is maintained, or the die is retracted at will.

Nature of the Tweddell riveter.

This machine consists of a riveting die and a holder, one or the other attached to and moved by a piston in a cylinder, which is called the compressing cylinder; this cylinder communicating with an accumulator through a valve, not self-acting, but moved by the operator, so that when the valve is opened the piston to which the die or the die holder is attached invariably moves until the rivet is headed, with a force which is positively defined by the pressure on the accumulator. Hence the work is performed without a blow; the pressure is uniform whether the rivets are long or short; it can be modified by the weights applied to the accumulator; it is continuous for each rivet, and may be maintained as long as desired, or the riveting die can be retracted as soon as the rivet is finished, whether the pump is taking water, delivering it, or at rest.

Accumulator.

The accumulator above alluded to is an essential part of the system, it is of variable capacity, in it water is kept under pressure, being forced in by means of a pump, or otherwise. The chamber of the accumulator is closed at one end, and to the other end is fitted a stuffing box, through which plays a weighted piston-rod or plunger. This plunger rises or falls as the quantity of water in the chamber increases or diminishes. By varying the load upon the plunger the

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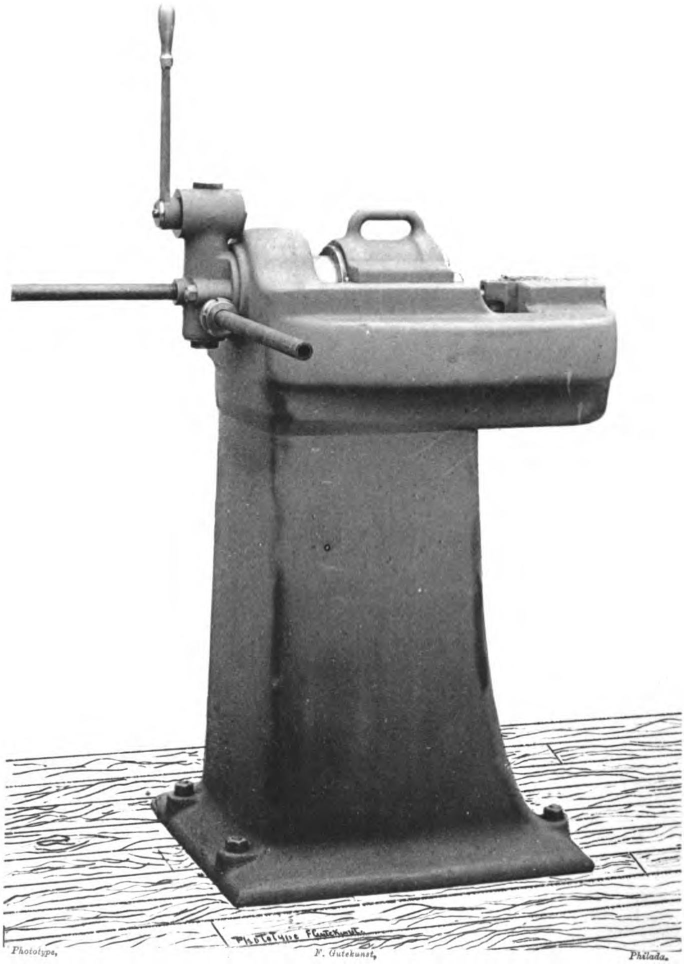
FIG. 92.



STATIONARY HYDRAULIC RIVETER. FOR ½-INCH RIVETS.

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pressure upon the water in the accumulator cylinder is adjusted. The water or other fluid under pressure in the accumulator, and there stored up ready for use, is conveyed through suitable pipes and admitted by the operating valve to the compressing cylinder of the riveting machine, so that when the valve is opened the water flows into the compressing cylinder, closing the riveting dies upon the rivet, and finishing the work with just such force or pressure as the accumulator has been gauged to produce.

Pump and accumulator.

The plant required for hydraulic riveting consist therefore of an accumulator that can be loaded so as to give any requisite pressure per square inch; a means of keeping this accumulator full by pump or otherwise; and the riveting machine proper, which may be either stationary or movable within certain limits.

STATIONARY HYDRAULIC RIVETER.

FOR ½-INCH RIVETS.

Arranged to drive ½-inch rivets in the cupped heads of small boiler or air cylinders. Will drive rivets in the head of cylinders 10 inches in diameter. Cylinder moves, and can be readily taken out to re-set the packings. Valve of improved construction, not liable to get out of order, and ready of access to its parts.

This very handy little machine was originally made to drive the rivets in the heads of the cylinders used in connection with the Westinghouse air-brake, and it is one of the tools best adapted to rivet in the heads of log boilers, such as are used with ranges.

See Fig. 92.

WITH our double pump accumulator it is quite possible to run one of these machines in connection with one of the larger riveters, provided the work done in size of rivet is constant and the machines are adapted to that pressure.

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ADJUSTABLE ACCUMULATOR AND PUMP.

Arranged with weights suspended below the main casting, so made as to be readily released from it to adjust the pressure to the work being done. These weights, four in number, gauging the pressure in equal steps from the lightest to one hundred per cent. increase over the lowest pressure. Main upright for the pump arranged with an improved sponge filter to clear the water before it enters the pump of all gritty matter; the filter has ready access for washing out by means of man-holes in the side of the upright. Improved relief valve, stopping the flow of water to the accumulator when it is full, but permitting the pumps to run full, ready for action but freed from pressure. Pumps double-acting, and fitted with improved attachments, to permit their quick opening to adjust or renew packings.

Our single pump accumulator has a pulley 16 inches diameter on the top of the upright, which pulley should make 250 revolutions per minute. Accumulator with two pumps has a pulley on the top of the upright 20 inches diameter 7 inches face, which pulley should make 250 revolutions per minute. In both these machines the belt is brought into action by means of a tightner attached to the machine, and the accumulator is best placed immediately under the main driving shaft, so that the belt will hang clear when it is not driving the pumps.

THE pump or pumps, which are double-acting, operated by crank motion, are of improved construction, and take water from a reservoir in the upright. The return water in entering the reservoir passes through a mass of sponge to filter it. An important feature in the arrangement of pump and accumulator is the adaptation of our improved relief valve to the system. This valve is so constructed and controlled by the motion of the accumulator as to relieve the pump from work without stopping its motion when the accumulator is full, and to start it to pumping into the accumulator as soon as the accumulator weight has descended a short distance. When this valve is open, the water under pressure in the accumulator is shut off from the pump, and the pump relieved from pressure draws

Water filtered.

Relief valve.

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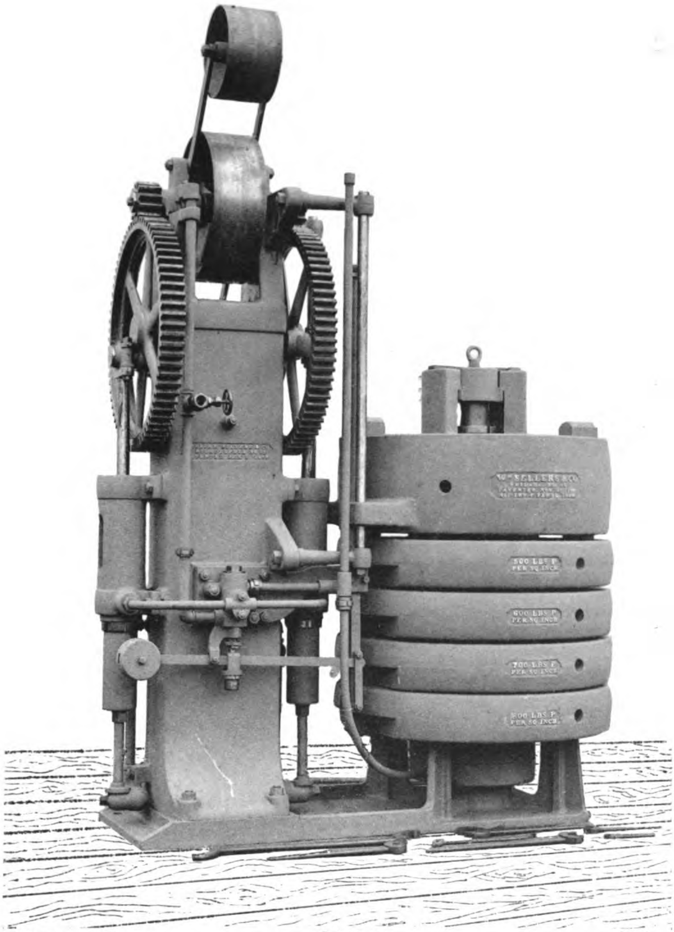
Fig. 93.



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PATENT HYDRAULIC ACCUMULATOR AND PUMP.

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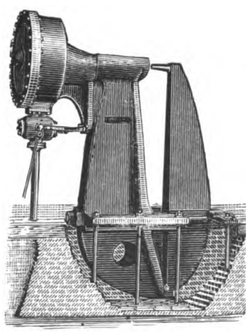
water from the reservoir and forces it back into the same reservoir, maintaining its action without strain, but ready to resume its work when required. When the relief valve is closed, the pump forces water directly into the accumulator. When the accumulator is full, and no water is being taken from it, the pump must either stop or discharge its water elsewhere. To stop the motion of the pump when the accumulator is full, involves its being again started promptly when required, which is not very readily done, and risks the loss of water and entrance of air into the chamber while standing. To maintain the action of the pump and discharge under a safety valve involves the expenditure of power when no useful work is being done. Our arrangement maintains the motion of the pump ready for immediate action, and yet relieves it from strain when not required to do any work.

Stopping pump.

Discharge under a safety valve.



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PORTABLE HYDRAULIC RIVETING MACHINE.

We make portable hydraulic riveting machines on the Tweddell system for various parts of bridge construction, and have introduced many improvements in the construction of the machines and in the attachments belonging to the machine, such as the cranes and conveniences for working the machines or handling the work.

Position in shop.

For bridge work construction in the shop,—the pump and accumulator are placed in any convenient position, and the water under pressure is carried through jointed or flexible pipes to a portable riveting machine suspended from an over-head carriage. In using this portable riveting machine the work resting on trussels remains stationary, the riveter is moved along it from rivet to rivet to be driven, performing the work with surprising rapidity and accuracy, and without noise or jar. The whole machine or combination is also arranged for use in the field, by providing a car with boiler, engine, pumps, and accumulator on it, the portable riveter being suspended from a crane or derrick attached to the car. This permits the use of the machine in driving the rivets in bridge erection or in ship-building.

Riveter for lattice girders.

We also make a direct acting portable riveting machine for driving the rivets in plate girders or lattice work. The openings in the throat of machine being wide enough to span the top and bottom chord and the over-reach sufficient to span the girder.

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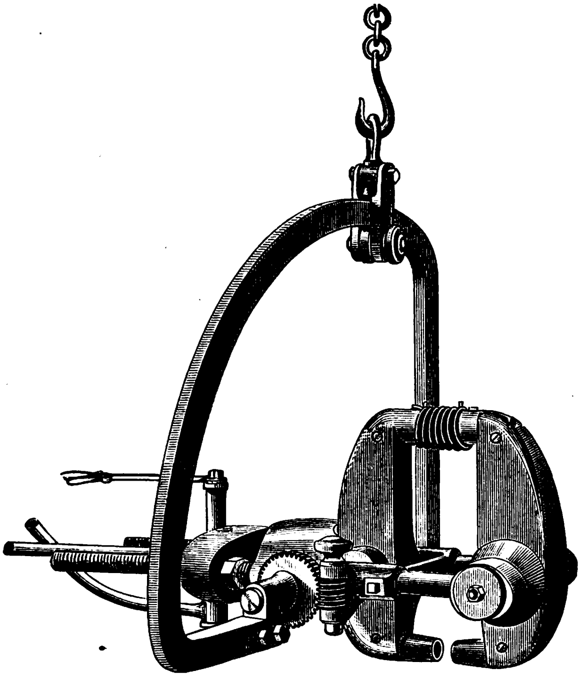
FIG. 94.



THE PORTABLE RIVETING MACHINE.

WE give in Figs. 94, 95, and 96, this useful machine in three positions; showing how it may be adjusted to act readily on seams oblique, horizontal, or vertical. Fig. 94 shows the shape of the riveting jaws or levers. The rivet is driven by the dies in short ends of levers. We make these levers or jaws of various lengths, suited to different work. In all cases the proportion of the two ends is as two is to one. Thus, we make lever 6 inches and 12 inches

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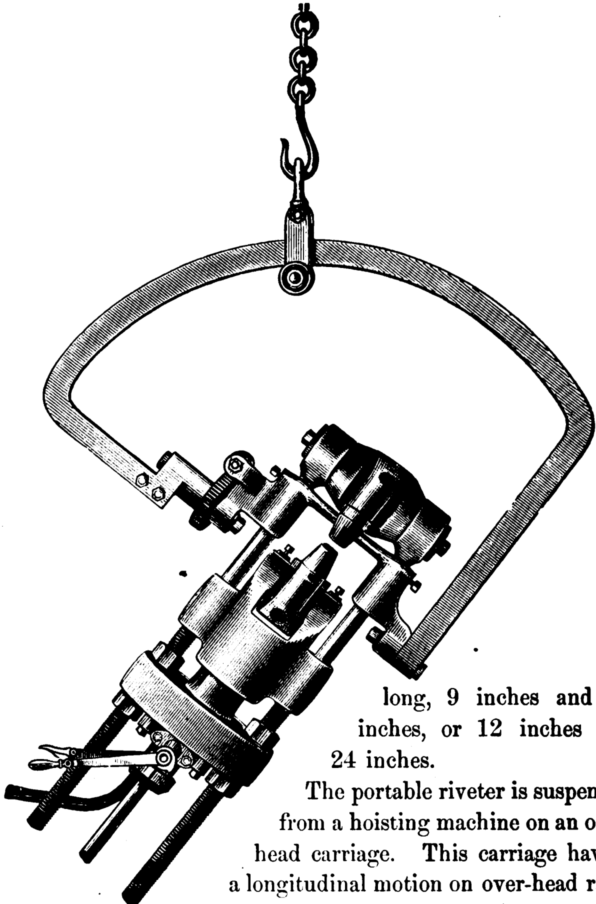
FIG. 95.



long, 9 inches and 18 inches, or 12 inches and 24 inches.

The portable riveter is suspended from a hoisting machine on an over-head carriage. This carriage having a longitudinal motion on over-head rails, of in some cases, 50 feet, and a transverse motion of 6 feet; thus permitting the use of the machine at any point within a space of 50 feet by 6 feet wide.

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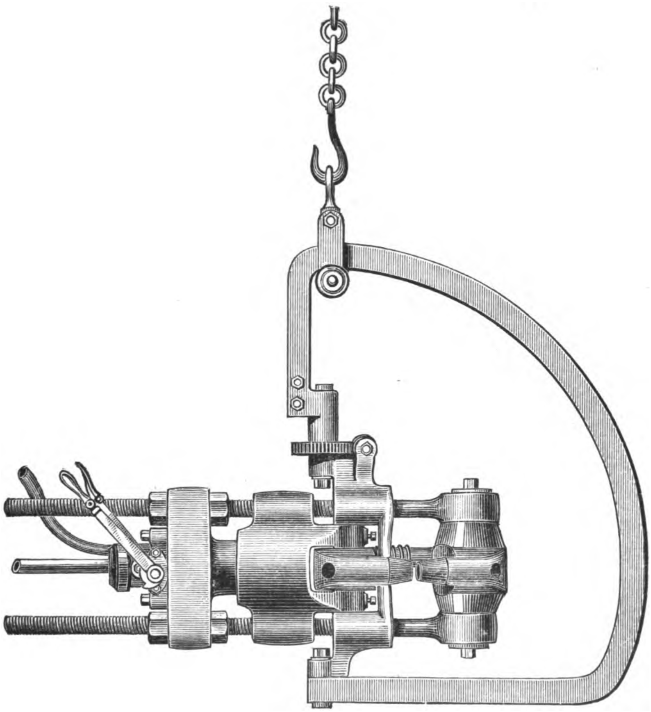
FIG. 96.



In this space the work rests on trussels and the riveting machine is moved along or around it.

One man raises and lowers the riveter, adjusts it to the rivets, and then closes the dies on the rivets. Boys drop the red-hot rivets into place with the head of the rivet uppermost in horizontal work. With a skillful operator, as many as 6 to 10 red-hot rivets may be put in place ahead of him, and he can, on beam work, drive from 10 to 16 rivets per minute. **Speed of work.**

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RIVET HEATING FURNACES.

In using the hydraulic riveting machine to advantage the rivets should be heated rapidly and uniformly. To accomplish this we have arranged furnaces inclosed in sheet iron covers, with every convenience for rapid handling of the rivets by the boys who attend to this part of the work.

OVER-HEAD CARRIAGE FOR HYDRAULIC RIVETERS.

Weston's patent hoist.

THE portable hydraulic riveter is suspended from an over-head carriage; the hoisting machinery of this carriage is one of the improved forms of Weston's hoists, working with very little friction, and capable of nice adjustment of the riveting machine to any position.

1000 lbs. hoist.

The same carriage with slight alteration can be made to lift 1000 pounds, and, mounted on the same ways as carry the riveter carriage, can be used to lift and adjust the work to be riveted. To obtain the best result with these riveters, the extra hoisting machines are desirable.

Estimate of Riveting plant.

We can estimate for riveting plant when informed of the kind of work it is to be used on, and the character of the building in which it is to be erected.

The hydraulic riveting machinery is inexpensive to maintain, if a very little attention is paid to keeping it in good order. It, like all other hydraulic machinery, should be kept up; not allowed to deteriorate by careless usage. Slight leaks, if stopped by attention to the packing at once, will give no trouble; if neglected, may amount to serious wear from rust and abrasion.

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BENDING ROLLS.

WE have recently made some important changes in the method of driving rolls for bending sheet and plate iron for boiler- or shipmakers' use. Before describing the tools, we would call attention to the principle involved in machines for bending plates of metal. The primitive bending machine still in general use consists of two rolls laid side by side and a third roll placed over these two, the top roll being adjustable vertically and being immediately over the hollow between the two lower rolls. In hand-power bending machines set up on this plan the levers to turn the rolls are usually attached to one end of one of the bottom rolls and the opposite end of the top roll. This plan is not admissible when rolls set up in pyramidal form are driven by power. Then it becomes necessary to gear the two bottom rolls, and frequently they are united by small pinions at one end. In such a case one bottom roll is driven, and that roll drives the other one through the pinions. The strain on the pinions coupling these rolls together is very great. The system is objectionable on this account and as involving much useless friction. We make hand-power bending rolls with the rolls set in pyramidal form, but never apply gearing and power to rolls so placed.

We are clearly of the opinion that the proper way to set bending rolls is to arrange two pinching rolls, one directly over the other, and both driven; then to place the bending roll to one side of the lower roll, with the housings so made as to guide the bending roll diagonally past the lower roll towards the upper one, as is shown in Fig. 97, page 274, in which the top roll A is placed directly over the bottom roll B. C is the bending roll adjustable towards A in the direction of the diagonal dotted line. When roller C is down far enough to have its top level with the top of roller

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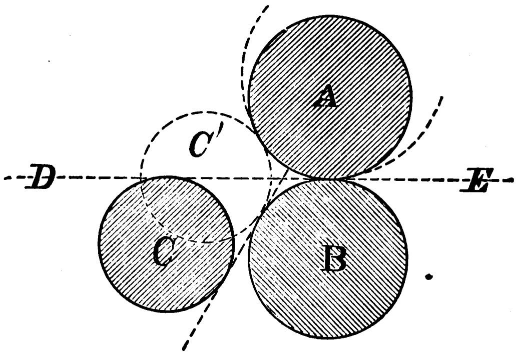
FIG. 97.



B, then a plate, D E, can be passed between rolls A and B without being curved; but when C is raised towards the position indicated by dotted circle C′, then the plate will be curved. We make several sizes and kinds of bending machines embodying the principle as shown above. In some we put bending rolls on both sides of roll B, thus making the set to consist of four rolls. Our most recent improvement will be found illustrated and described on page 165 as our 10-foot power bending rolls.

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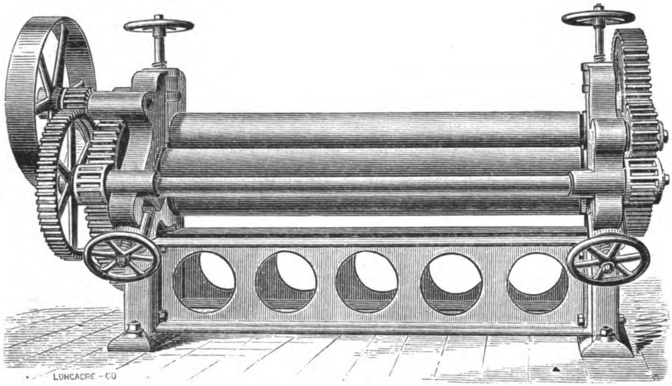
FIG. 98.



POWER BENDING ROLLS.

Arranged with two pinching rolls, set one directly over the other, the bending roll movable at an angle to the pinching rolls. Pinching rolls geared at opposite ends, so that they are always correctly in gear while driving. The top pinching roll removable through housings at one end, so as to permit the bending up of flues. Over-head shaft with ball and socket hangers and three pulleys, 24 inches diameter, 5 inches face, for reversing by open and cross belts, which pulleys should make 180 revolutions per minute, requiring on main line a driving pulley 15 inches face.

ROLLS arranged as above present the advantage of being able to squeeze the plate between the two pinching rolls and bend nearer to the edge of sheet than can be done with three rolls set in the usual manner, *i.e.* two on a horizontal plane and one over the space between these rolls.

Bend near to edge.

We are prepared to make Power Bending Rolls for

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For ship work. ship work, with four rolls in the system adjustable by power in height; these rolls are massive and can be used for bending plates 1 inch thick and 14 feet wide; will bend cylindrical or in-wind, while the sheet is passing straight (not diagonally) through the machine. These rolls can also be used for straightening plates in a much more thorough manner than can be done with hammers: they are intended for ship work. All

For large boiler plates. the rolls have centre supports. We also have designs of a similar set of 4 rolls for boiler work, to take in plates 11 feet wide, having all the advantages of the above.

BENDING ROLLS.

Made of best gun iron, for boiler plate; with strong iron frame, self-supporting top, and side rolls adjustable, to set on floor without foundations, with rolls 5 inches in diameter, 4 feet 6 inches long.

Same machine with all the rolls adjustable, housings and boxes complete, fitted to bolt on foundations.

Rolls 8 inches diameter, 6 feet 1 inch long.
" 9 " " 6 " 1 " "
" 9 " " 8 " 1 " "

THE first machine described in the above specification is intended for tank work, bending iron of not over $\frac{3}{16}$ inch thick; is admirably adapted for tank work, and can be used to advantage in coppersmith shop for rolling up pipes. The larger rolls are of the usual hand-working kind, and require pits at each end of the rolls for the lever arms to work in. The housings are independent, and must be secured to foundation.

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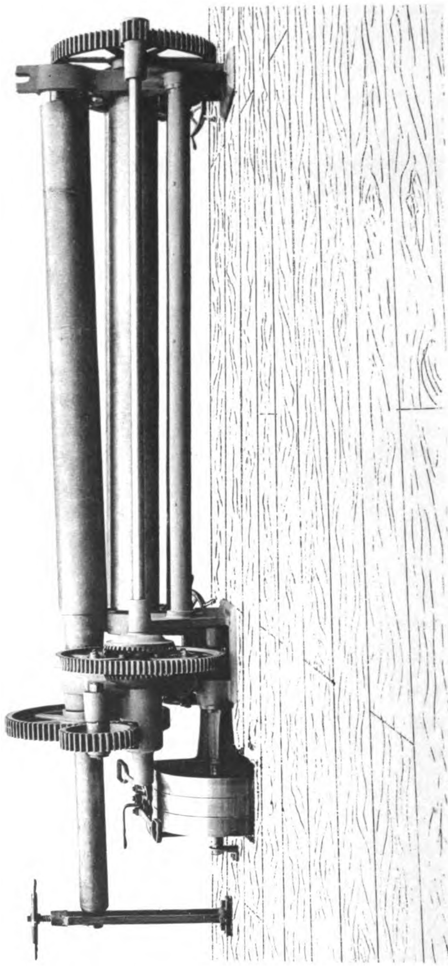
FIG. 99.



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BENDING ROLLS.

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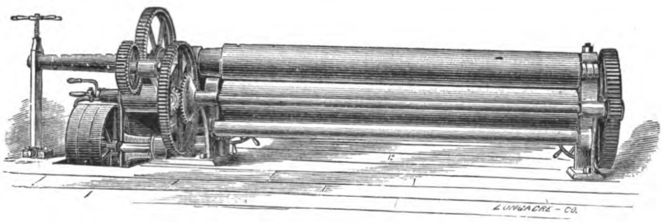
FIG. 100.



10-FOOT POWER BENDING ROLLS.

Arranged with two pinching rolls, set one directly over the other, the bending roll movable at an angle to the pinching rolls.

Pinching rolls geared at opposite ends, the power being transmitted through a set of equalizing wheels, so as to rotate the rolls in proper relation to each other, and thus avoid any calendering motion on curved plates. The top roll made to tilt up at one end for the ready removal of flues, or sheets rolled into a full circle.

Arranged with patent belt shifting gear the same as on our planers and hoisting machines. Pulleys, 30 inches diameter, 4½ inches face; pulley on line to drive the machine must be 13 inches face, turned straight, and of such diameter as will give a speed of 178 revolutions to a 30-inch pulley.

AFTER much experience with machines for bending plate we designed this tool, and have introduced in it the improvements alluded to on page 273. It will be observed that the shaft which conveys the motion from one roll to the other is arranged with a set of equalizing gear wheels. The bevel pinions equalize the strain upon both rolls. When a plate of iron, ¾ inch thick, is curved into a cylinder, say 4 feet in diameter, it will be found that the

Equalize motion.

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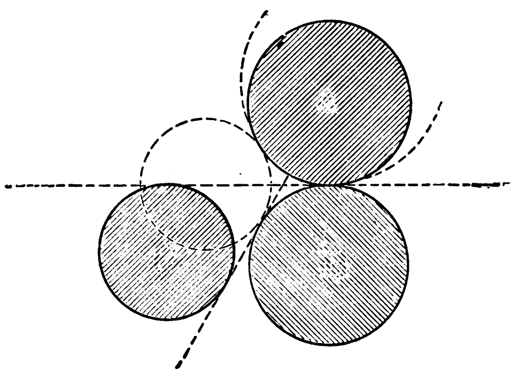
difference between the outside and inside circle of the sheet will cause a motion of the equalizing pinions of about ⅓ of their circumference. Rolls geared in this manner require less power to drive them than would be needed to drive rigidly geared rolls of the same size and length. This machine can be used to straighten sheets as well as bend them.

Straightening sheets.

The above arrangement of rolls is shown below in section.

FIG. 101.



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POWER BENDING ROLLS FOR SHIP WORK.

Arranged with two pinching rolls placed one over the other, and having two bending rolls, one on each side, moved up at an angle towards the pinching rolls. The rolling or pinching rolls are 16 inches in diameter, 14 feet long, and have three supports. The bending rolls are 12 inches in diameter, and these too have three supports,—that is to say, the end journals of the rolls and a centre support. All the movable rolls are moved up or down by power. The top roll of the pinching pair is stationary. The lower roll moves up to it to clamp the plate. The movement of these rolls is by means of worm wheels and worms, and the raising mechanism of the bending rolls is so arranged as to permit the three bearings of each roll to be set up at one time and at the same rate of speed, or to be separated, and thus to permit the rolls to be set in-wind to the required curvature in the plate, and when so set to be continued in their motion in the same position or inclination. The pinching rolls are driven at the opposite ends by powerful gearing and independent pulleys, so that each is at all times driven to the best advantage, without any calendering motion, as when both rolls are driven from one belt and one set of gearing. There are two driving pulleys, one at each end of the machine, and these pulleys, 40 inches in diameter and 8 inches face, must run at the rate of 120 revolutions per minute. Separate belts, open and crossed, are used to drive the adjusting machinery. The rolls will bend plates in-wind or straight while passing straight through the machine. Can also be used to straighten or flatten buckled plates.

IN bending plates for ship work, not only is required to bend heavy plates, but they must be bent in-wind to suit the shape of the ship's side. The design of ship bending rolls given in the above specification is adapted to bending or straightening plates of iron 1 inch thick and 14 feet wide. The curvature can be made regular or in-wind, the plate in either case passing directly through the machine, not diagonally. The great weight of the rolls necessitates the moving of all parts of this machine by power. In

Will bend 1-inch plates.

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How to straighten plates.

using the machine to straighten buckled plates, the bending rolls are set so as to take the plate level without bending, and the parts of the plate to be stretched, to free it from the buckle, have slivers of sheet iron placed on them, when in passing through the pinching rolls these parts will be submitted to greater pressure, due to the thickness of the superimposed slivers of sheet iron, and will be stretched in such places,—a very little practice on the part of the workman enabling him to effect the ready straightening of plates in a better and quicker manner than can be accomplished by hand hammers.

CUPOLAS FOR FOUNDRY PURPOSES.

With cast iron foundation plate supporting the columns which carry the cast iron base plates and doors for discharging waste contents, after heat; wrought iron case, wind chambers and valve, charging door and elbow to chimney so arranged as to deposit all the cinder at base of chimney. The whole fitted complete, with fire brick ready for lining the curved portion immediately above boshes.
Diameter of boshes: 24, 30, 36, and 42 inches.

A VERY excellent form of cupola, simple in construction and giving a good result in melting. The interior is of a shape to hold the lining with certainty, and to permit the placing of the tuyeres in any required position in the circle and of any number.

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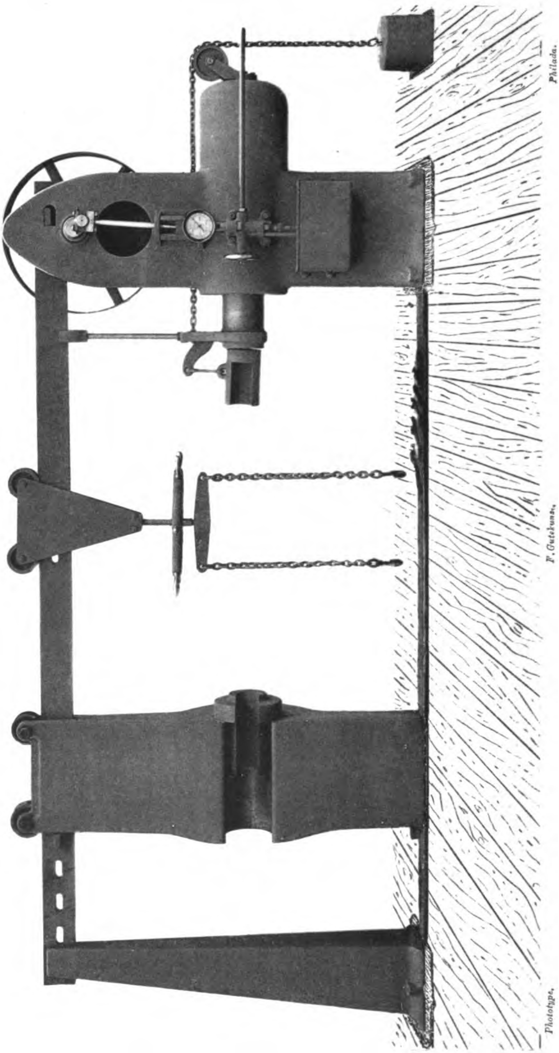
Fig. 102.



72-INCH HYDROSTATIC WHEEL PRESS.

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HYDROSTATIC WHEEL PRESS.

Of capacity for putting two driving wheels upon the axle at the same time. Cylinder lined with copper in an improved manner. Double-acting brass pump arranged with pressure gauge and stop valve, and improved safety valve to prevent overloading. Chain slings and elevating screws for wheels and axles traveling on top rail of press. The resistance beam or post is suspended from wheels on top rail and movable to any position, thus acting equally well for pulling off and pushing on. Wrought iron work case hardened. Over-head shaft, with ball and socket hangers and fast and loose pulleys. We make five sizes of machines, as follows:

Name of Machine.	Pressure.	Stroke of Ram.	Size of Fast and Loose Pulleys on Counter-shaft.	Speed.
84″	200 tons.	24″	48″ × 8¼″	100 Rev's.
72″	200 "	24″	48″ × 8¼″	100 "
54″	200 "	24″	48″ × 8¼″	100 "
42″	150 "	18″	36″ × 7″	100 "
36″	150 "	18″	36″ × 7″	100 "

THESE machines, three for driving wheels, which takes in 84-inch, 72-inch, and 54-inch wheels, and the two for car wheels, which take in 42-inch and 36-inch wheels, have a power of 150 tons for the latter and 200 tons for the former. This power is not expected to be used to its full extent in pushing on wheels, but in pulling off those that have become rusted fast. In practice, it has been found that

Force required for car-wheel.

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car axles made cylindrical (not conical) in the "fit," if made .007 inches larger than the hole in the wheel, require 30 tons to force on, and will never come loose in use. The value of the hydrostatic wheel press over any form of screw press is in the possibility of always noting the pressing force used. On some of the screw presses made it has been found necessary to adapt a hydrostatic cylinder and pressure gauge to resist the force of the screw, and thus indicate the pressure used. This led to the use of hydrostatic forcing machines exclusively, and the present machine is the result of many years' experience with this way of forcing on wheels, which experience indicated a rather short durability to the early machines, not lined with copper.

Iron cylinder not lined will break.

Method of lining.

Those which we make are provided with copper-lined cylinders made without any break in the continuity of the lining, insuring durability. This method of making the cylinders is of great importance. The safety valve, which is inaccessible to the workman, will not permit a greater pressure than 5000 pounds to the square inch being obtained, and its spring is at all times relaxed except during the time of the press being in action, thus giving it ample time for rest and insuring its constant accuracy. The pump is of the best bronze, and is double acting. Fluid used is oil, and when the pump wheel runs 100 revolutions per minute the motion of the ram is seemingly constant. This is important, as with single acting pumps the wheel goes on with jerks.

Safety valve.

Use oil.

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HYDRAULIC MACHINES.

Hydraulic pumping engines—Hydraulic accumulators for high and low pressures—Platform hoists, operated by water—Hydraulic moulding cranes for car wheels.—Also large water cranes for foundry use, arranged with very superior valves, and designed with especial view to durability and convenience; as well as hydraulic punching, riveting, and forging machines.

HAVING been engaged for many years in the manufacture of hydraulic machines, we have accumulated a large assortment of patterns of the various useful appliances of this very convenient mode of transmitting power and of using it in machines. We are prepared to furnish all that may be required for the introduction of hydraulic motors and machine tools into warehouses or workshops.

Transmitting power by water.

The very great convenience of the hydraulic system of working hoisting machines has caused its introduction into some of our largest works, and the improvements introduced recently have tended to materially decrease the first cost of the plant needed. This first cost, which may seem great when a single machine or hoist is to be operated, becomes trifling when the use of the power is extended to a wider range of machines. Thus, in any event a pumping engine and accumulator are required; but when these two machines are in place a very considerable number of machines or hoists may be operated from the same source of power with less cost for each machine, and very much less cost of conducting the power to it, than by any other known method. In this country the use of this power has been mainly confined to hoisting machines; but we have recently extended its use to all purposes of shearing, punching, and riveting machines, as also to forging presses and like purposes. We give on page 288 a cut of a very convenient crane for moulding pur-

Pump and accumulator.

Use in this country.

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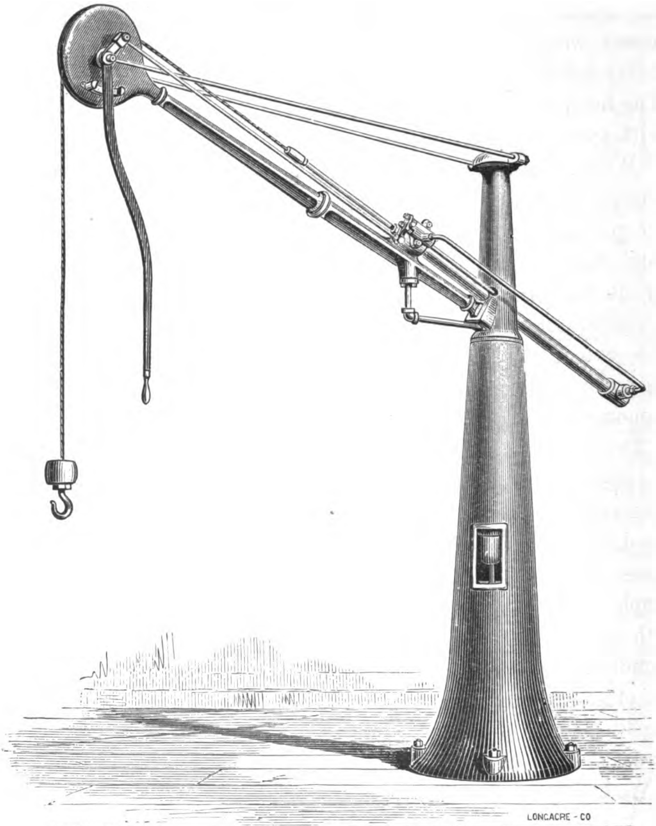
Fig. 103.



HYDRAULIC MOULDING CRANE.

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poses,—one of the series of machines designed by us for the use of the Pennsylvania Railroad Company in their wheel foundry at Altoona. In this machine the weight is raised and the empty hook lowered by power, with very little loss of water, so that the usual heavy ball at hook is not required, facilitating its use. The hand lever is near to the work, thus dispensing with an assistant to move the valve.

Water lifts for Pa. Railroad.

We have also arranged convenient ladle-tilting machinery for car-wheel foundry, and automatic cranes for placing the red-hot car wheels in the annealing pits. Some of the machinery of this description made by us has been in operation for more than fifteen years, without any notable need of repair. We have also extended its use to other machines for special purposes, clearly demonstrating the advantage and economy of the mode of operation.

Ladle-tilting machine.

The universal employment of the hydraulic system in the operations incident to the Bessemer process has rendered many persons familiar with its use; but while the direct-acting crane commonly used in handling the ladles and ingot moulds in the Bessemer mills seems simple and convenient, it is wholly inadmissible with the greater loads and higher lifts needed in foundries. We recommend for foundry cranes the use of steam as preferable to water cranes, but where the lift is not very high we can arrange hydraulic cranes to hoist, rack in and out, and turn by power.

Use of water cranes in the Bessemer mills.

Foundry cranes.

We have patterns for breaking machines for casting, one having a lift of forty feet, weight of drop one ton, and a smaller one of ten feet lift and one ton drop.

Breaking machines.

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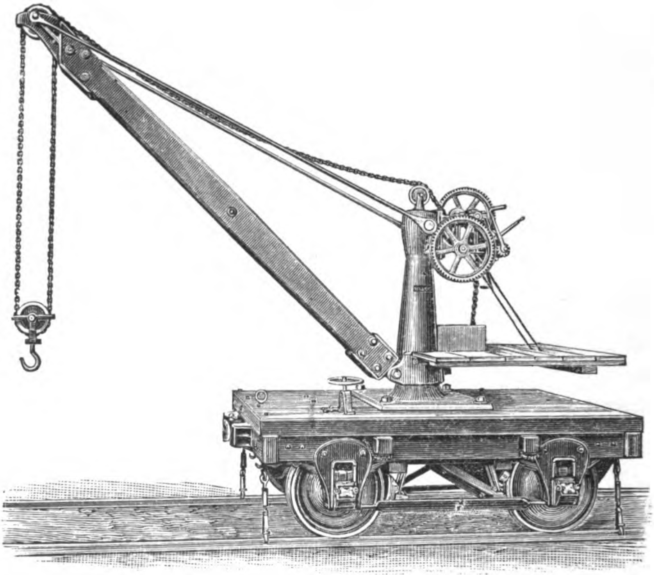
FIG. 104.



5-TON WRECKING CRANE.

With cast iron post mounted on railway car of any required gauge of track. Gearing for fast and slow motion. Strap brake on large gear-wheel. Chain controlled by sprocket and guide wheel; not winding on a drum. Clamps to fasten car to rail while hoisting.

THIS crane was designed in the first place for use on South American railroads, the crane to accompany goods cars and to be used in loading and unloading freight at way stations.

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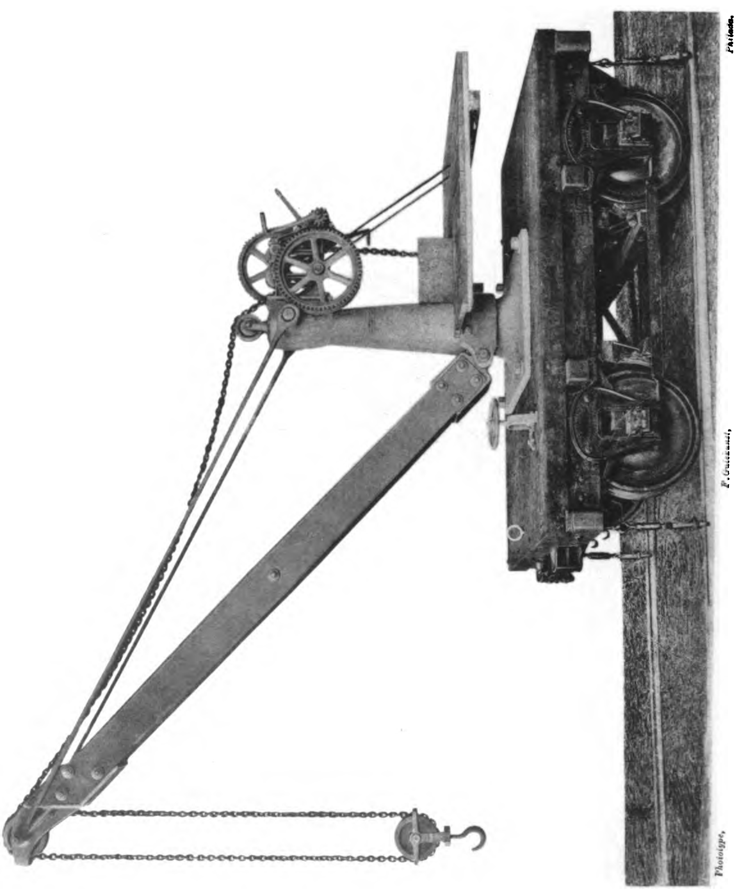
Fig. 105.



FIVE TON WRECKING CRANE.

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The chain passing over sprocket wheels is coiled in a box on the platform. This arrangement permits the use of a very much longer chain than is admissible when wound on a drum in the ordinary manner, and diminishes the size, parts, and amount of machinery required in the hoisting gear. While hoisting the car can be clamped to the rails by means of adjustable clamps arranged to hold the car in four places. Car is hung on springs; but blocking pieces are provided to wedge up the springs when hoisting.

Long chain.

Clamps.

We are also prepared to make cranes like the above for heavier weights, up to, say ten tons, but think a long car with two five-ton cranes on it preferable for some kinds of work. The cars can, in building, be adapted to any gauge of track.

MOULDING CRANE.

With cast iron bed plate 9 feet 3 inches square, mounted on four wheels 48 inches in diameter; the gauge of track upon which it is to run being 9 feet 10 inches. Radius of jib swing, 11 feet 7 inches; distance from top of rail on floor to sheave at end of jib, 10 feet; hoisting machinery so arranged as to be self-sustaining, thus avoiding all danger of running down; platform for operator attached to centre post, from which position the load can be hoisted and the carriage moved upon the track. The whole complete with wire rope, and ball hook.

A VERY convenient crane for use in foundry for moulding car wheels, or similar work; will answer for weights of 1500 pounds. The wheels upon which it is carried, being 48 inches diameter, admit of its passing over flasks 22 inches high, above the rail.

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CRANES FOR FOUNDRY PURPOSES.

With cast iron base and top plates; double set of gearing upon the base plate, so as not to be affected by the straining or shrinking of the timbers; top sheave frame iron, arranged to move the whole length of jib by means of a chain wheel near crank shaft; sheaves bushed with steel and revolving upon steel pins; ball and socket hook; the whole complete with all necessary chain, wire rope, bolts for timber work, and rails for top sheave frame.

5, 10, 25, and 50 ton crane.

AN important feature in these cranes is the arrangement of the jib and over-head carriage. Instead of making the jib horizontal, and carrying the hoisting chain from extreme end of jib over the sheaves, and thence back, over a sheave near the post, to the drum, we carry the chain from drum direct, diagonally to the carriage, and make the end fast to the lower block; then, with three upper and two lower sheaves, we hang the load on five strands of chain, instead of on four, as is usual, and thus work with much less friction. We drop the jib towards its end, so as practically to make the load more level in running it out and in. This enables one man to run the carriage and load, either out or in, with ease and dispatch.

Load on five strands of chain.

There are two powers to the machine, and a means of shifting quickly from the one to the other, or to lock. We have patterns suited to 16 feet, to 25 feet, and also to 31 feet, height of room. The latter patterns are the most recent, and have several important features. They are capable of winding up a large amount of chain, so as to work in a room 31 feet high without having to override the chain on the drum. We have also adapted a patent brake to these large cranes, which enables the load to be held in any position, and lowered by friction, without danger to the workman.

Two powers to machine.

Chain on drum.

Patent brake.

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25-TON STEAM SWING CRANE.

WITH WROUGHT IRON FRAME.

Fitted with two engines operating the gearing through improved friction clutches, so arranged as to permit all the functions, hoisting or lowering, racking in or out, and turning about the centre, to be performed at one time or separately. The steam-engines, two in number, and the main working parts are carried on a cast iron base plate, to which the wrought iron work of the crane is attached. Slow gearing of hoist lifts the maximum load, 25 tons, with engine running 250 revolutions per minute, at a speed of hoist of 6 feet 6 inches per minute; the fast gearing, with same speed of engine, hoists 5 tons at the rate of 31 feet per minute. Racking out is done at the rate of 78 feet per minute and turning the crane about its centre one and two-thirds of a revolution per minute. Sheaves all bushed with steel. Ball and socket hook. Complete with all the chains and wire ropes and attachments for steam pipe at top of crane and for exhaust pipe at the foot of the crane. Arranged to be worked by hand when steam is not available.

Wrought iron framework adapted to the requirements of the location and service, substantially constructed on an ample factor of safety.

THESE very effective cranes are well adapted for use in foundries or machine-shops, and are readily erected. The cranes are provided with the usual slow and fast gearing, for heavy and light loads, and these are so arranged as to accomplish the same direction of rotation when hoisting in either gear. This is very important, as it makes all the motions of the working levers the same for the same functions in either gear of the machine. The crane is turned by means of a pinion travelling in a stationary gear-wheel, which is bolted to the foundation. The platform upon which the workman stands is made to cover this gear-wheel, and the space occupied by all the machinery is so small and so close to the post as to make the working area of the crane

Slow and fast gear.

Platform for workman.

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large. The working parts are readily fended from dust at the discretion of the purchaser. All the parts are made durable, and where wear is likely to occur provision is made for ready repair. We use a friction clutch, which permits the load being started slow, no matter what may be the speed of the engine at the time. We provide an efficient brake, but when a load has to be sustained for any considerable time it can be held by throwing the fast and slow gear in at the same time. The clutches for this purpose are never both out of gear at the same time, one is part in gear when the other engages, and if left in this position the load will be prevented from overhauling the chains. In designing the frames of these cranes we prefer to droop the jib in a regular curve, so laid out as to permit the load to travel level when racking out, and to attach one end of the hoisting chain to the lower or hoisting block. This gives five strands of chain to carry the load in place of four, as is the case when one end of chain is made fast to the out end of the jib. It also is of great advantage in diminishing the amount of sheave rotation when racking out. If, in the case of very low roofs, it is not possible to use the drooped jib, we resort to the use of four strands, and carry the chain from the end of the jib over an extra wheel near to the post and thence to the drum. We arrange the chain drum with grooves and a throw-over piece to compel the overlap chain to start when the length of hoist makes the over-running of the chain a necessity. But in all cases where it is practicable we prefer making the drum large enough to take all the chain without overlapping.

Friction clutch.

Locking gear.

Drooped jib.

Chain drum.

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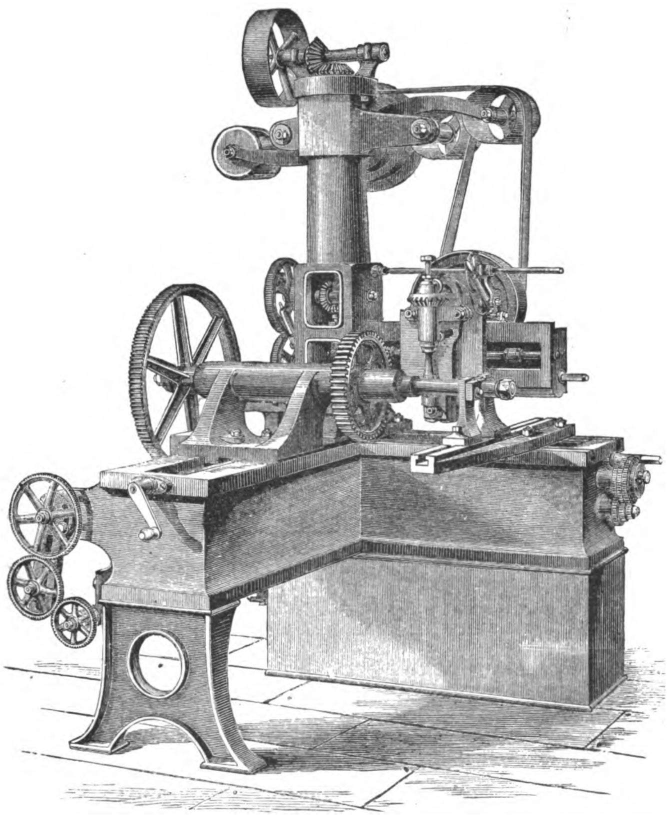
Fig. 106.



GEAR CUTTING AND WHEEL DIVIDING MACHINE.

Automatic in all its motions; arranged to cut bevel and spur wheels to 4 feet 6 inches diameter and 9 inches face. Division made by wheel and tangent screw carefully constructed. One full set of change wheels to effect division of wheels from 10 up to 360 teeth. Feeds self-acting and variable.

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GEAR CUTTING AND WHEEL DIVIDING MACHINE.

(*For Report of Judges, see page* xvi.)

Capacity. THIS machine is arranged for cutting both spur and bevel wheels, has a capacity up to 54 inches diameter of wheel, 12 inches face, and will cut a number of small spur wheels of same size at one time. It is entirely automatic, performing all its work after adjustment, without attention of workman, to the completion of the wheel being cut or divided.

Mode of dividing. The division is obtained by a tangent wheel and worm very carefully constructed, and the designated number of teeth is obtained by use of change wheels (a full set of which accompanies the machine), and the turning of the handle *P* (see cut) for change 1, 2, or 3 times, as may be called for on the schedule of division. This turning of the handle, however, and all other motions, are done by the machine itself. Thus, a blank wheel being put in place and the proper cutter adjusted to depth of teeth, length of stroke of cutter head, etc., the cutter will pass across face of wheel-cutting space between two teeth, will then return at a quick pace to the starting side of wheel, the blank will then be turned to present a second space to be cut, and the cutter will start its proper motion, all the changes being made by the machine itself, not by the attendant workman. To forcibly illustrate the merits of this machine, it may be said that in method of dividing, speed and power of cut it does not materially differ

Quantity of work done. from other well-made gear cutters, but in quantity of work done, one machine has been found, on similar work, to do one and a half times the work done by a

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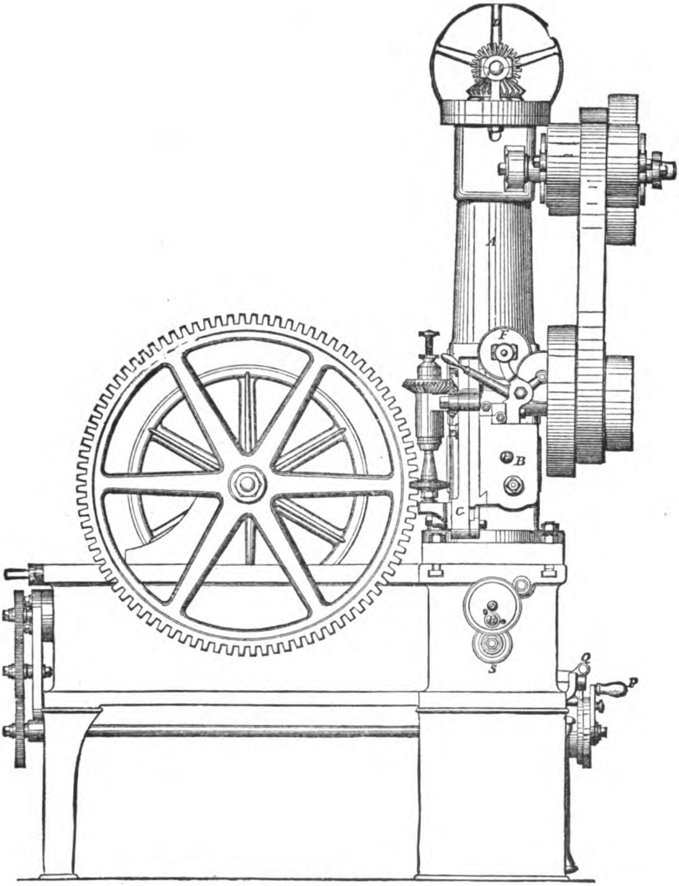
FIG. 107.



skillful man on a gear cutter of equal power operated partially by hand. In practice one man can advantageously attend four of these machines; each machine

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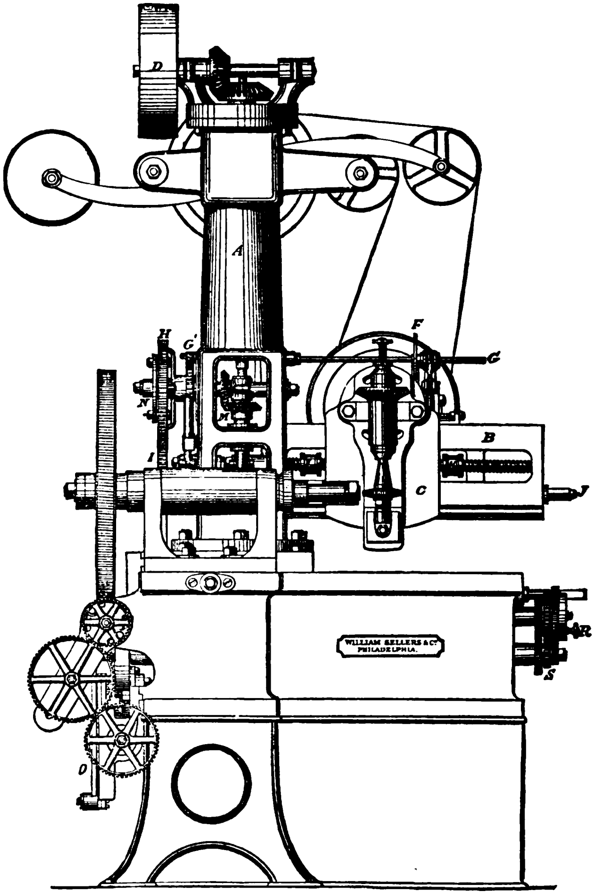
Fig. 108.



doing much more work than a hand machine, and really using but one-fourth of a man's time. Too much stress cannot be laid upon this as an example of

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labor-saving machine tools, and as an argument in favor of such tools. Counter-shaft has 14 inches fast and loose pulley, 4 inches face for $3\frac{3}{4}$-inch belt; 120 revolutions per minute. **Speed.**

On pages 299, 300, we give two cuts in elevation. In Fig. 107, a spur wheel is drawn in position to cut. In cutting small wheels a number are placed side by side on the one mandrel and the pass of the cutter made over all wheels at once. When a long mandrel is used for this purpose a steady rest should be placed at its outer end; and when light wheels of large diameter, or any wheel that will spring sideways under cut, is being operated on, a rest block should be placed against the edge of the rim so as to resist the pressure of the cutter. The use of the friction feed discs, shown at *F* in cuts (107, 108), enables the feed speed to be varied to the proper amount to suit each case.

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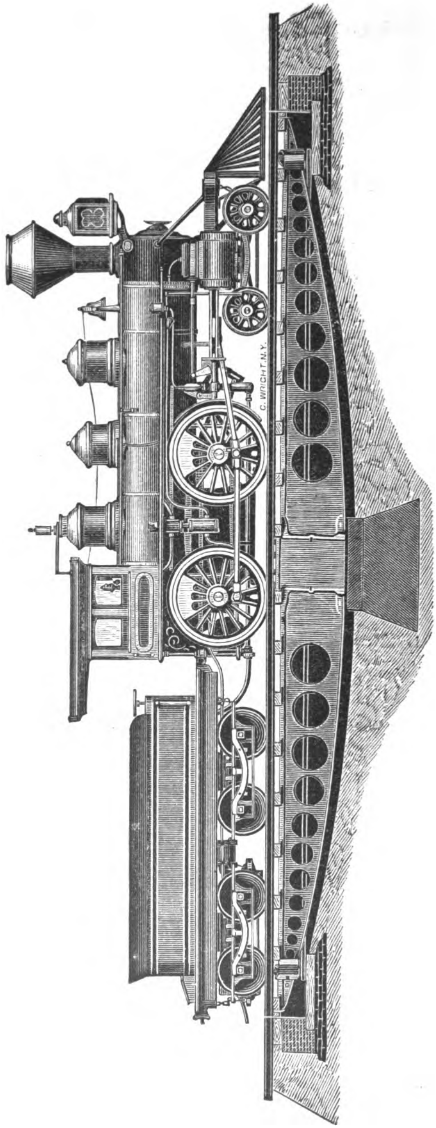
Fig. 109.



RAILWAY TURNING TABLES.

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RAILWAY TURNING TABLES.

DIMENSIONS OF TABLES.

	60′ Table.	56′ Table.	54′ Table.	50′ Ex. heavy Table.	50′ Table.	45′ Table.	40′ Table.	30′ Table.	12′ Table.	9′ 4″ Table.	9′ 4″ Table.
Diameter of Pit . . .	60′ 1″	56′ 1″	54′ 1″	50′ 1″	50′ 1″	45′ 1″	40′ 3″	30′ 4″	12′	For heavy Freight Cars no Pit required.	For City Passenger Cars no Pit required.
Diameter of Circular Track	56′	52′	50′ 2¼″	45′ 10″	45′ 10″	41′ 4″	36′ 5″	27′	10′ 6″		
Distance from under side of rail on Table to top of Table Casting . . .	5	5″	5″	5″	5″	5″	5″	5″	5″		
Distance from top of Table Casting to top of Centre Stone	4′ 1″	4′ 1″	4′ 1″	3′ 10¾″	3′ 7¾″	3′ 7¾″	3′ 1¾″	2′ 5″	2′ 5″		
Size of Centre Stone . .	6′ sq. by 15″ thick.	6′ sq. by 15″ thick.	6′ sq. by 15″ thick.	5′6″sq. by 15″ thick.	5′6″sq. by 15″ thick.	5′6″sq. by 15″ thick.	5′ sq. by 12″ thick.	5′ sq. by 10″ thick.	5′ sq. by 10″ thick.		
Height of rail on Table, when level, above rail on road	½″	½″	½″	½″	½″	½″	⅜″	¼″	¼″		
Height from under side of rail on road to top of Centre Stone	4′ 5½″	4′ 5½″	4′ 5½″	4′ 3¼″	4′ 0¼″	4′ 0¼″	3′ 6⅜″	2′ 9¾″	2′ 9¾″		
Height from under side of rail on road to top of Circular Track . . .	1′ 9½″	1′ 9½″	1′ 9½″	1′ 8½″	1′ 8½″	1′ 8″	1′ 8⅜″	1′ 8¼″	1′ 10½″		

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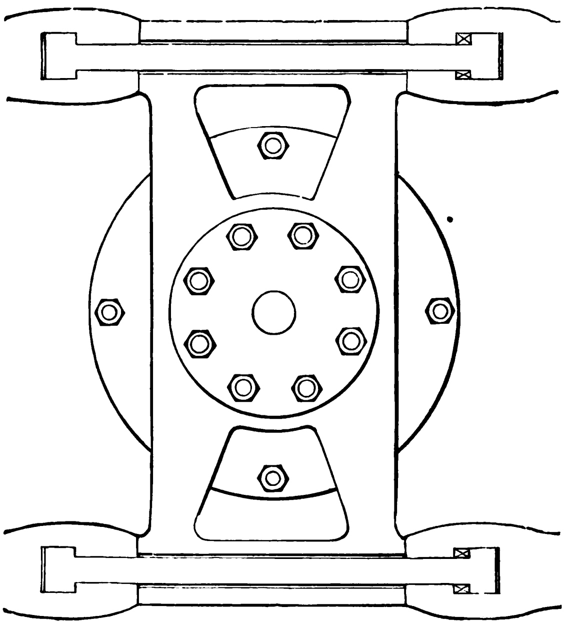
RAILWAY TURNING TABLES.

SINCE our introduction of cast iron turn-tables for railroads, we have made many hundreds of them, of all sizes, and their use has extended over the greater part of both continents of America. They are simple in form, very durable, and easily put in place, requiring comparatively inexpensive pits, and turn with ease.

FIG. 110.



Arms. The table proper consists of four cast iron arms or beams, of proper shape for strength, firmly bolted, and secured to a cast iron centre box of requisite width.

Centre box. In the centre of this box is placed the peculiar pivot

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upon which the table turns. At outer ends of the arms are cross girts carrying wheels to swing clear of a circular track rail, and upon which rail these wheels rest when the table tips, but they swing clear of it in turning. **Cross girts.**

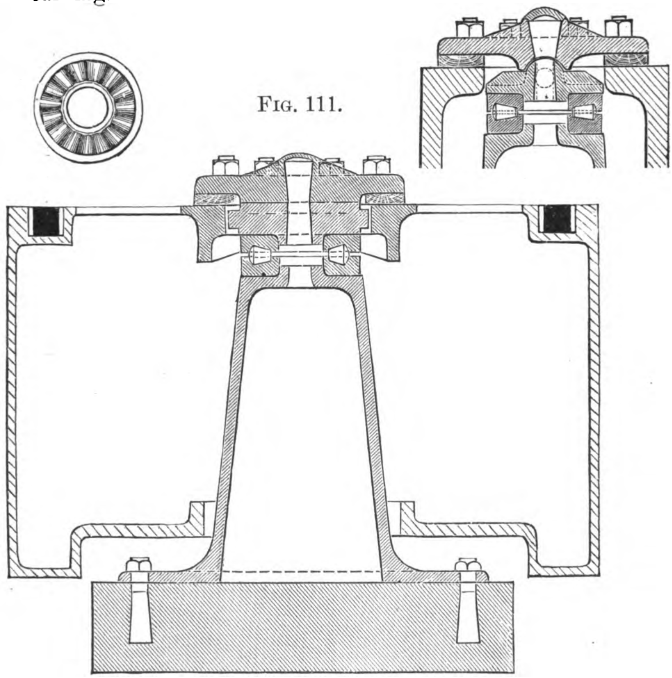

FIG. 111.

In the centre of the pit is placed a conical centre post, with a broad base resting on a firm foundation of stone. This post extends nearly to the top of the centre box. The top of post is made hemispherical, and on it rests a cast iron cap, carrying a set of steel plates grooved and filled with conical steel rollers. The whole weight of table and engine rests on these **Post.** **Steel plates and rolls.**

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steel rolls in turning. A cap of cast iron rests on the top steel plate, and to this cap the centre box is suspended on a circle of bolts, with a layer of wood between the box and cap. By taking out this wood and thinning it or adding more to it, the table can be adjusted in height. Upon the arms cross ties are laid, and to these ties the rail similar to that on the road is secured. The pit is usually built with a curbing of stone, and in the centre must be built a strong foundation of a size suitable to carry a top stone of the size prescribed in our list of dimensions. The pit is deepest in the centre, and grows shallower towards the circumference, ending in a level plateau for the reception of the circular track. This track should be carefully leveled, and should rest on well-laid sills,—stone or iron preferable to wooden sills. We have made gearing for turning these tables, but its application is worse than useless. One man, with a lever of such a length as will extend over the curbing of the pit, can, with ease, turn the heaviest engine. The power required to turn a table 50 feet in diameter, weighing over 24,000 pounds, was tried in our works, and it was found that one and one-half pounds pressure, applied at one end of the arms, was sufficient to start its motion from a state of rest. We make provision for adapting a cover to the entire pit, but it somewhat impedes the ease of turning; and in most cases the covered pit has been abandoned, even in round-houses, and the pit left open. The distance from top of curbing to circular track is so little—about twenty inches—that the pit may be crossed by stepping down into it, if necessary. It may be noted, also, that as the steel plates and rolls upon which the table turns are near to the top of the table, the pit

Layers of wood for adjustment.

Centre foundation.

Form of pit.

Circular track must be level.

Geared table.

Power required to turn.

Covered pit.

Depth of pit.

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may be almost filled with water without interfering with the motions of the table, other than the resistance offered by the water. The introduction of steel centre plates and steel rolls in place of cast iron ones, as was our early practice, has made them very much more durable, and increased the ease of turning. Attention being paid to these rolls, they are practically indestructible. They should be occasionally cleaned, —once every three months, at least,—and at all times kept well oiled. Oil mixed with tallow, so as to be soft in cold weather, will answer a good purpose. In case of the breakage of any part by accident, such as an engine being run into the pit with the table out of place, etc., the broken parts can be readily replaced with new ones, as all the pieces are planed to gauge and are interchangeable; but if arms are broken, we should be advised if the broken one has key-ways at the large end where the T bolt fits into the recess in arm. In regard to diameter of table to suit any particular case, the larger diameters are the best, as the engine, either with empty or with full tender, can be most readily balanced; and it is necessary that the centre of gravity of the load be in all cases brought over the centre of the table, so as to have no appreciable weight on the circular track. When these tables were first made, 40 or 45 feet in diameter seemed to meet the case of the engines then in use; afterwards the increase of weight of rolling-stock compelled the introduction of 50 feet; still later of 54 feet, 56 feet, and 60 feet lengths. The 50 feet table having been placed in many round-houses and other positions where the larger sizes could not be conveniently used, the increase of weight of engines called for an extra heavy 50 feet table. This is designed to fill the want in such cases as the above, and

Water in pit.

Steel in place of cast iron for plates and rolls.

Must be kept clean and oiled.

Ease of repair

Send description of broken parts.

Diameter of table.

40 and 45 feet tables.

50 and 60 feet tables.

Extra heavy 50 feet table.

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is adapted to the heaviest engines that can be turned in such a diameter of pit; while the regular 50 feet table answers a good purpose for roads having engines of 25 or 30 tons weight only. The gauge of road has nothing to do with the width of table: hence we sell the same table for 3 feet and 3 feet and 6 inches gauge as we do for the 4 feet 8½ inches and 5 feet gauge. For 6 feet gauge we recommend our 54 feet size and over, as being wider in the centre box. The table 30 feet in diameter is intended for use in freight-depots for turning cars; has been used on coal roads for turning at "tips," and in one or two cases has been made with platform-scale attached, to permit weighing on the cars and load while on the table. We also make smaller sizes for shop use and for street passenger railways. The former of these is 9 feet 4 inches diameter, and is heavy enough to permit loads as great as can be readily got on that diameter being turned. The pit is shallow, and the table covers the entire opening. The latter table, for street roads, is lighter, can be readily put in place in the street, and offers no obstruction to the ordinary travel of carriages, etc. It is provided with a lock that is operated by keys in the hands of the drivers, and which cannot be tampered with by others using the street. This was called for to prevent boys from playing with the tables. The use of these small tables has extended to all our principal cities. Our remarks upon care of the steel rolls apply to these tables, which turn in cast iron conical rollers.

Gauge of road. For 6 feet gauge. 30 feet table for cars. Tables for shop use. Shallow pit. For street passenger roads. Mode of locking.

We make to all sizes of tables an improved locking gear, when ordered; but in the majority of cases the purchaser arranges his own mode of locking them.

Locking gear.

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CENTRAL SUSPENDED TURN-TABLE FOR SWING BRIDGES.

We would request the attention of bridge-builders, engineers, and others to our Improved Central Suspended Turn-tables for Swing Bridges.

This system secures economy in construction, great durability, and admits of a high speed of operation at a comparatively small expenditure of power.

The turn-table is arranged to carry the whole weight of the pivot span, upon a set or sets of steel rollers, working in grooved steel plates, after the manner of our turn-tables for turning locomotives. A cylindrical cast iron centre box suspended from the top cap, which rests on the steel plates and rolls, is so arranged as not only to afford ready access to the steel plates and rolls, but also to permit their removal, as well as the removal of the central conical post upon which the steel plates and rolls rest. From the centre box radial arms are projected to the under side of the chords of the bridge in such direction, as to furnish the best points of support for the bridge, and at the same time to carry a circular upper track for the rim wheels, which in this case are made to steady the bridge but not to bear the load. The radial arms are modified to suit the conditions of the bridge structure, and consist of struts and suspension members of steel or iron. The steel plates and rolls are made with one or two series of rollers, the size in all cases, as well as the number of rollers, being such as will insure their working with the whole load of the pivot span in turning, with a pressure on each roller well within the limit that will assure practical lubrication.

The swinging gear consists of one or two sets of pinions and shafts, having their bearings on the drum, and acting on a fixed circular rack, bolted to the wheel track. This swinging gear can be arranged to be operated by hand, steam, or other power.

THE ease with which locomotives can be turned on our improved cast iron turn-table for railway purposes, early led to the inquiry for the application of the same principle to tables of swing or pivot bridges. The success of this principle depends upon the entire weight of the superstructure being carried on the centre, and resting on the steel conical rollers placed there to receive it. With tables as ordinarily made this was not readily done. Hence, in practice, much of the weight of the bridge is carried on rollers placed on a circular track near to the outside

Entire weight on centre.

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of centre pier. Our central suspended turn-table was designed to meet this want, and is applicable to all forms of swing bridges. We so arrange the structure as to insure the entire weight being carried on the centre plates, and we use the track rollers only to take the tip of the table. These track rollers we make the same for all weights of table, using more or less of them in the circle as the case requires, but never expecting that any of the load shall rest upon them. The pivot span is carried on the ends of radial arms projecting from a cast iron central box, these arms being formed of struts and tie rods of steel or iron. The number and arrangement of the arms being suited to the conditions of the bridge structure. These arms, also carry the top circular track drum, made of I beams, curved to shape, and shod with a cast iron track bevelled to correspond with the taper of the conical rollers in the live circle. The rollers for circular track are carried in a wrought iron spider frame, and rest on cast iron segments placed in the stone work of the centre pier; to these segments are secured the toothed segments into which the pinions gear that do the turning.

Applicable to all forms of superstructure.

Track rollers to prevent tip.

Circular.

Tie rods and struts.

For bridges of 300 tons and under, the turning is always done by hand, but to larger sizes we have sometimes adapted steam turning machinery; in which case we so arrange the steam power in the centre drum or on the outside of it as the case may require, and all the motions of unlocking and loosening the ends of draw as well as turning are done at centre, and are effected by power, in either direction and at variable velocities. When turning by hand, two men can with ease turn a bridge of 260 tons weight. The chief engineer of the P. F. W. & C. R. R. reported

Steam machinery for turning.

Power required.

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that a table of our construction, on the South Fork of the Chicago River, with a bridge of 260 tons weight, was used during seven months of the year 1868, as follows: **Example.**

Number of vessels passed	43,735	
" " times swung	16,984	
Travel of ends of bridge	1,077	miles.
" " of men in turning	1,517	"

This table has required no repairs, can be opened and closed by two men in 45 sec. each way. When asked for bids on these tables, we should know—

Dimensions required.

1. Weight of bridge, resting on table.
2. Distance from centre to centre of chords.
3. Whether two or three chords.
4. Nature of bottom chord (width and general character).
5. Available height for table, between high water and the under side of chord.
6. Distance from top of masonry of pier to under side of rail in road, or to under side of roadway (should be about 8 feet, if possible).
7. If to turn by hand or steam power.

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RAILWAY TRANSFER TABLES.

THE most convenient form of building for locomotive and car shop, seems to be that in which independent stalls are arranged in line side by side. This calls for some convenient form of transfer or sliding table to shift engines or cars bodily sideways. We have, to meet this want, designed a wrought iron transfer table, formed of I beams riveted together, upon which the rails are laid. The structure is carried on four or six pairs of 36-inch wheels, resting on two or three tracks laid lengthways of the pit; the tracks being 6 feet gauge. The pit is lined at bottom, and very shallow, being only 11½ inches from base of rail on road,—*i.e.* from top of table to top of rails in pit; and as the pit may be paved level with the top of rails in it, it is practically but 11½ inches deep, and offers no impediment to those wishing to cross it. The frame of this table is well adapted for the reception of a vertical boiler and engine to move the table by power, and where much work is to be done this is economical. We also adapt hand operating gearing to these tables when required.

We also make a cast iron table twenty-eight feet long, requiring a deeper pit, but arranged with gearing to move the table by hand.

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WILLIAM SELLERS & CO.'S

SYSTEM OF SHAFTING.

REVISED 1883.

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SHAFTING.

(*For Report of Judges, see page* xxii.)

We furnish, upon application, a price list, in which we call attention to the following mechanical advantages of our system, we having made the construction of Shafting a *specialty:*

1. All sizes are made to standard gauges.
2. The *Double Cone Vice Coupling* admits of quick and very easy attachment and detachment.
3. The *Double Braced Ball and Socket* hangers are light but very strong, and readily adjustable in every direction.
4. *Long Journal Bearings* held so as to always insure a uniform distribution of pressure over the entire length of bearing.
5. The appropriate distribution of metal in Pulley Castings, giving the greatest strength with the least quantity of material.

The introduction of a scale of fixed prices for every separate article, enables the consumer to know in advance the *exact sum* his work will cost, thus giving a great advantage over the purchase by the *pound*, the amount of which is generally indefinite. Purchasers of our Improved Shafting will make not only a direct saving in first cost, but a continual one, by the acquisition of a well-constructed and easy-running system for the transmission of power, very neat in appearance, and as light as is consistent with the requisite strength; our extended experience having enabled us to establish correct proportions without any undue expenditure of material.

Fixed scale of prices.

HAVING been engaged since the year 1848 in the manufacture of shafting and mill gearing, during which time we have introduced a fixed scale of prices for the various articles comprised under the name of "Shafting," we have from time to time made important improvements, and, by the introduction of special tools, been enabled to very much reduce the cost of the articles needed in this line.

Shafting considered as a machine.

In any large factory the shafting, with its couplings, pulleys, and other adjuncts, considered as a machine to transmit motion, is most frequently the largest in the establishment: hence every consideration of economy

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requires that it should do its allotted work with the least possible loss of power in the transmission. It calls for economy in first cost, and economy in use.

The generation of power to be expended in operating machines to do work costs something; it may cost much money in fuel consumed, or it may cost something in energy expended. In any case, the more perfectly the whole power is transmitted to the work, the more profitable will be its use.

History of improvements.

It is a noteworthy historical fact, that economy in the generation of power in the motor, and economy in the utilization of the power in the machine, have been in most countries far in advance of the economical transmission of power from one to the other. Years ago there were excellent models of water-wheels, and by them were driven machines of surprising ingenuity, but the power was conveyed by means of cumbersome wooden shafts upon which were wooden drums for the driving belts; gearing too, made of wood, slow-moving, awkward contrivances for the purpose, and very wasteful of power.

Early engineers in iron took model from the practice with wood.

In the progress of the art, it is quite evident that early engineers in iron took their ideas from what had been done in wood. They copied in iron what had been the practice in wood. Cumbersome, slow-moving iron shafts took the place of slow-moving wooden shafts. Gear wheels were used to transmit the power from the motor to the shafts, and from shaft to shaft in the various rooms and situations requiring power; while belts or bands from pulleys were only used to transmit the power from the shafts to the individual machines.

Belts *vs.* gear wheels.

The practice of high-speeded shafts, and the entire substitution of belting for gear wheels, belong essentially to this country.

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The value of high speed in belts has been long known in England and in some parts of Europe, and many wonderful examples there exist of its application. These examples are, however, exceptional, and have not come to be general mill practice.

Mr. R. Willis.

It may be well to note that in a book published in London in 1841,—"Principles of Mechanism," by Robert Willis, M.A., F.R.S.,—mention is made of the use of belts, and what was the practice in America at that time, in these words:

"Belts, on account of their silent and quiet action, are very much employed for machinery in London, to avoid nuisance to neighbors. It appears, also, from a recent work,* that the use of belts is greatly extended in American factories. In Great Britain the motion is conveyed from the first moving power to the different buildings and apartments of a factory by means of long shafts and toothed wheels, but in America by large belts, moving rapidly, of the breadth of 12 or 15 inches, according to the force they have to exert."

What Prof. Willis says in regard to American practice has continued to be the practice since this was written, but has been vastly extended; here the employment of wider belts and faster-running shafts has become more general, while this extensive use of belting obtains in very few cases abroad, even up to the present time.

Use of gear wheels limits the speed.

The use of gear wheels to transmit the motion from one shaft to another limits the speed at which the shafts may be run. Too high a speed causes the teeth to break even when doing no work,—*i.e.* when the load

* Cotton Manufacture of America, by J. Montgomery, 1840, p. 19.

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is off. With belt-driven shafts any convenient speed may be obtained, and thus the smallest possible size of pulleys on the line be used. To obtain the high speed found advantageous in modern mill practice, the shafts must be straight and truly cylindrical; they must be united by couplings that hold them firmly, and be provided with bearings that will maintain the shaft in a true line, so as with proper lubrication to reduce the friction to a minimum. Since the introduction of turned iron shafts, a great many contrivances have been used to unite shafts. It must be borne in mind that the coupling should be of such a nature that the strength and rigidity at the joint shall be as great, if not greater, than in any part of the line, so that if the line be subjected to flexure, it will bend anywhere else than in the coupling. In England, up to the present time, it is considered good practice to make the ends of all shafts larger than the body of the shaft by forging, and then to these enlarged parts secure the couplings by various and sometimes expensive means. Shafts so enlarged at the ends cannot be made to receive carefully bored pulleys, unless the pulleys be made in halves, bolted together upon the shaft. Shafts come from the rolling mill, of certain merchantable sizes, as round iron. These round bars, when turned so as to be of uniform diameter, should be united without the extra cost of enlarging the ends.

With belts high speeds are possible.

Requirements of a good coupling.

English practice as regards couplings.

The first really good coupling used for this purpose was what is known as the plate coupling. This coupling (Fig. 112) consists of two plates, with stout hubs, fitted with great care to the ends of the shafts to be coupled, and the plates then held together by very carefully fitted bolts, *a a*, which are turned and fitted

Plate coupling

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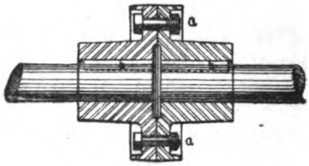
into reamed holes. There are also keys (*b*) provided to prevent the couplings turning on the shafts. This,

Fig. 112.

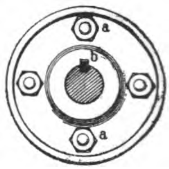


when well made, is an excellent form of coupling, but it has manifest disadvantages; its first cost need not be very great, but it requires too much care in fitting.

Use of keys in plate coupling.

We have said that keys are used to prevent its turning. They must be put in as a precaution, not as an actual necessity, and must be made to fit on their sides, not on their top or bottom. (See Fig. 113.)

Fig. 113.



How plate couplings are fitted.

The coupling is usually bored to some standard size, say $\frac{1}{16}$ of an inch less in diameter than the body of the finished shaft. The ends of the shaft are turned, in the case of a 4-inch shaft, .015 of an inch larger than the hole in the coupling; key seats are cut in the shaft and in the coupling, and a parallel

Key.

key fitting sideways, not top and bottom, is laid in the keyway in shaft, and the coupling forced on by a powerful press with say from 20 to 30 tons pressure.

The effect of taper keys.

If a plate coupling be so fitted as to slide on and off easily, and an attempt be made to hold it in place by a taper key, fitting top and bottom, the pressure on the shaft will be on two opposite lines only, and

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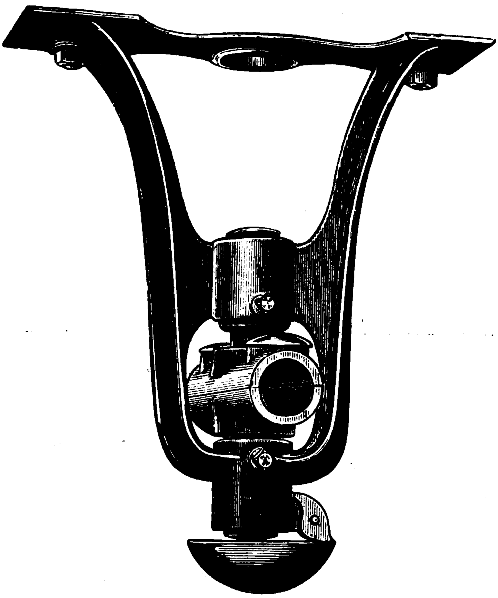
sooner or later such coupling will work loose. To drive in a taper key is the very surest way to break or burst the surrounding metal, or at least make it run out of true. We cannot too strongly condemn the use of taper keys in all similar cases. A plate coupling, when properly fitted, requires great force to remove it, when its removal is needed for the placement of pulleys on the line, and frequent removal in-

FIG. 114.



jures its fit. It also necessitates the use of open-sided or hook hangers, as the coupling cannot be put on after the shaft is in place. These hangers, for equal strength, require double the metal used in a hanger with metal on both sides of the box. (See Fig. 114.) The greatest objection, however, to the use

Obliges use of open-sided hanger.

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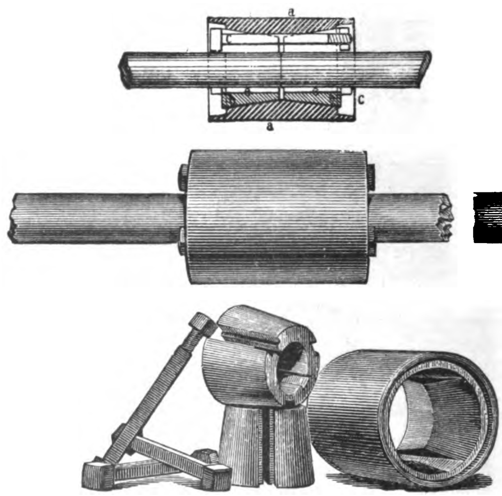
of this and similar kinds of coupling is in the fact that skilled labor is required to insure accurate fits, and that no practicable system of inspection will enable the mill owner to know that the fits are good ones. The working out of any shaft from its coupling may result in the fall of the section of shaft, the breaking of valuable machinery, or, too often, the loss of life.

No inspection will insure perfect fits.

1856.

Previous to the year 1856 we used the plate coupling exclusively, with a hanger made open on one side. Desirous of insuring accuracy of fit of coupling

Fig. 115.



Patent coupling.

independent of the skill of workmen, we, during that year, introduced a coupling which, while it fills all the requirements of absolute security, can be cheaply made, and admits of ready removal and ready adjustment when pulleys, etc., are to be added or changed.

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This coupling (Fig. 115), which we have called the double cone vice coupling, consists of three principal parts,—an outer sleeve, *a*, and two inner sleeves, *b b*. The outer sleeve has its interior surface made like twc frustums of cones, with the apex of each meeting in the centre of the sleeve. *b b* are conical sleeves, bored to fit on the shafts intended to be coupled, and having their outer surfaces so turned as to fit into the conical holes of the outer sleeve, *a*. The cones *b b* have three equidistant square slots cut in them, and there are corresponding slots on the inside of the outer sleeve. These slots are to receive square bolts, *c c c*. The sleeves *b b*, when put into place in the outer sleeve, will not quite meet,—*i.e.* they are too large to go in all the way. They are, however, split, each one, in one of the square slots at *d*. This split makes them elastic, and if they be forced into the conical holes they will contract, and thus diminish the size of the centre holes. The square bolts, *c c c*, while they serve as keys to prevent the inner sleeves from turning, also serve as a means of drawing the conical sleeves towards one another; so that if the ends of shafts be in these sleeves, such ends will be pinched or held fast by the pressure, and that in proportion to the force used in screwing up the bolts.

Outer sleeve.

Inner sleeves.

Bolts.

An important feature to be noted is, that one cone cannot be drawn in with any more force than the other one; the resistance is the pressure on the shaft ends. The pressure on both ends of shafts in such a coupling must be equal, and is under the control of the person using and applying the coupling. The shafts need not be of exactly the same size; shafts of an appreciable difference in size may be as firmly held as if they were of the same diameter. Key slots are

Equalizes the pressure on each end.

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provided as a precautionary matter, as shown at *e e*; but the keys must, as we have before stated, fit sideways, and not touch top or bottom. That the shafts united by this coupling need not be of the same diameter is a very important consideration, and leads us to dwell for a moment on an important feature of shafting, viz., its *cost*. Machines can readily be constructed to turn bars of round iron in the condition they come from the rolling mill to a nearly uniform size, with great rapidity and at a very small cost. The expression, *nearly uniform*, we use advisedly. We mean that shafts can be turned so that a standard hardened gauge can slide over them and seemingly they will be of uniform diameter; but a careful measurement would show them to be only approximately alike in size. They are what may be called commercially accurate. This commercial accuracy represents a certain cost of production. Absolute accuracy, were such a thing possible, would represent a cost many times greater. Commercial accuracy is attainable by machines and by unskilled labor; absolute accuracy would involve more costly processes and the utmost skill of the most experienced workmen. When the plate coupling was in common use, the bodies of the shafts were made of one size, and the coupling ends reduced by skilled workmen to a smaller size and carefully fitted to the coupling. It was this fitting that was costly. With the cone coupling this fitting is dispensed with, and shafts are sold as they come from the turning machines. An adjustable coupling, to be good for anything, must clamp each end uniformly.

Commercial accuracy.

There are, and have been for years, many forms of adjustable couplings in use which do not fill this

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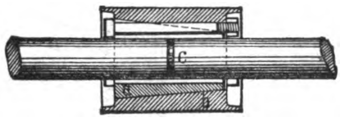
requirement. As an example, one shown in Fig. 116, in which one long conical sleeve, *a*, fits in a conical hole

Single cone coupling.

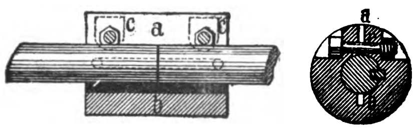
FIG. 116.



in the outer sleeve, *b*, and the shafts to be coupled meet in the centre, at *c*. The cone (*a*) being split as are the cones in the coupling before described, the conical sleeve, when forced in, will be compressed upon the two ends of the shafts, provided these ends are of exactly the same diameter; but if one is ever so little larger than the other end it will be held, and the smaller end will be loose, and, what is more, no amount of pressure exerted by the bolts will make such a coupling hold the smaller one as firmly as the larger end. So, again, a coupling made as shown in Fig. 117, which represents a plain cylindrical sleeve,

Require ends of shafts to be of uniform size.

FIG. 117.



split through at *a* and partly through at *b*, so as to render it elastic, and is compressed by bolts *c*,—such a coupling will hold shafts of exactly the same size, but will produce an unequal pressure on shafts of slightly different diameters. In practice, this latter coupling is made to hold by means of a peculiar key,

Sleeve coupling.

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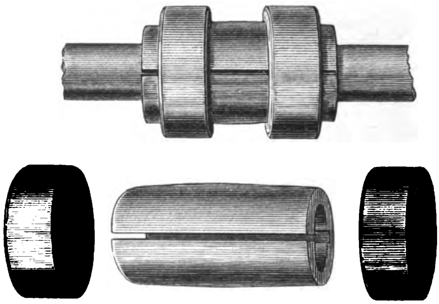
which extends over the two ends of the shafts to be united, and is provided with pins at its end, fitted into holes drilled in each shaft.

Fig. 118.



Banded coupling for light shafts.

Fig. 118 shows a modification of the last mentioned coupling, in which a sleeve, split its entire length, is turned on its outside high in the centre, and over the conical shapes so produced there are driven iron bands, coned inside to fit the taper of the shell. This coupling, like others of its kind, serves a fairly good purpose in the case of very small shafts, say under 1½ inches in diameter, where the work done is light, and comes into use in the shafting erected to drive sewing machines.

How to remove patent coupling.

While on the subject of adjustable couplings, it may be well to remark that in putting them on the shafts they should be put on with a view to removal. All parts should be well and carefully oiled, so as to avoid all chances of their rusting fast. And in event of required removal it is best to slack up the bolts, and if not then loose, a few blows upon the outer shell with a billet of wood may start it loose. In case of the double cone coupling, a wedge, say a cold chisel,

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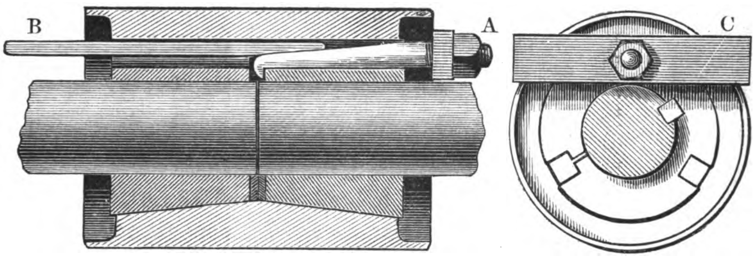
driven into the split in inner cone seldom fails to loosen the cones and free the coupling.

To meet the case of the coupling having become rusted fast to the shafts, as may happen when long exposed in damp places, we give in Fig. 119 the ob-

Fig. 119.



vious device for effecting the ready separation of the cones. The tool consists of a hooked bolt A, a wedge B, to hold the hook of the bolt down to place, and a piece of flat bar iron C, with a hole through it for the bolt, all as shown. Take out all the bolts of the coupling and insert hook bolt in the manner indicated in cut, and so draw out the cone. This is a readily made tool, and is a handy device to have on hand when many changes are made in shafts fitted with the double cone coupling. When shafts are very much out of line, from the sinking of some part of the building to which they are attached, bending of the shafts subjects the couplings to a very considerable strain, and they are so proportioned that they are quite capable of withstanding all the strain which the shafts can bear with safety. When so out of line, our coupling can be unbolted without any fear of accident to any part

Tool for parting the coupling.

Uncoupling shafts when out of line.

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of it; in fact, the strain on the coupling at such time materially aids the separation of its parts. We do not know of any coupling fulfilling to any degree the requirements of an adjustable coupling that can be safely parted under the strain caused by any considerable bending of the shafts at the coupled parts, while some couplings cannot be separated at all unless the shafts are free from strain, because such strains cause the parts of the coupling to bind.

Test of the cone coupling. When the double cone coupling was first made, it was subjected to severe trials to test its utility. The experiment was made by coupling two shafts, which were placed on three bearings 10 feet apart, the coupling being near to the middle one. The hangers were so placed as to bend the shaft $1\frac{3}{4}$ inches out of line. These shafts so coupled were then made to revolve 250 revolutions per minute for many weeks during working hours, and yet the coupling did not loosen under this severe strain. We also separated the shafts by uncoupling while they were thus so severely bent, and with no harm to any part of the coupling. Since that time they have been made by thousands, and are in use in all parts of our country, and many have been sent abroad. We use special machines in making these couplings, and parts can be supplied to fit couplings in use.

Next to the proper means of uniting the shafts, come the devices to sustain the shafts and permit them to revolve freely on their axes.

Mr. E. Bancroft. About thirty years ago, Mr. Edward Bancroft, then engaged in the machine business in Providence, R. I., **Swivel hanger.** invented what was called the swivel hanger. In order to insure the weight of the shaft being received over the entire length of the box, he hung the box in a

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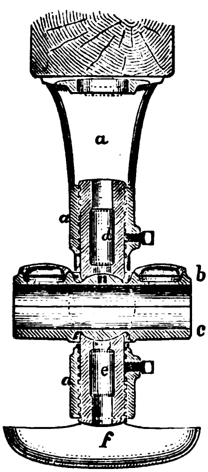
kind of universal joint and made its axis of vibration coincide with the centre of the box. This permitted the use of longer boxes than were heretofore practicable, and the pressure per square inch on the surface was lessened. Before the introduction of the swivel hanger, rigid bearings were the only kind used,—we mean bearings which could not adjust themselves to the positions of the shafts,—and such rigid bearings are still used in Europe. When Mr. Bancroft had demonstrated the great advantages of the swivel or self-adjusting hanger bearing, he showed it to most of the prominent machine builders in the New England States, and tried to introduce it generally; but not one could be found who was willing to undertake its manufacture. They characterized it as a needless piece of refinement, and far too costly to be generally used. Mr. Bancroft afterwards, in connection with Mr. William Sellers, under the firm name of Bancroft & Sellers, manufactured this hanger, and introduced it extensively.

Rigid bearings.

FIG. 120.



This swivel hanger was afterwards superseded by what is called the ball and socket hanger, now in almost universal use in this country, which is the same in principle but differs in detail. Various circumstances have, from time to time, caused modification in the form of the supporting frame, but the principle has remained unchanged. Fig. 120 shows a section of the modern hanger. The part marked *a*

Ball and socket hanger.

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Frame of hanger.

is the frame or hanger; *b*, the top box, and *c*, the bottom box, the two halves united, forming what is called the "box,"—*i.e.* the journal box or bearing: the bearing in which the shaft rotates. This box is provided, top and bottom, with spherical surfaces, so placed as to be, in reality, portions of a sphere which has its centre in the centre of the axis of the box; *d* and *e* are what are called the plungers. These are screwed into the frame, and are provided with cup-shaped ends to clasp the spherical parts of the box. The box can rock to a limited extent in every direction in these cup-shaped ends. The plungers serve a double purpose: 1st, of providing the socket for the sphere to roll in; 2d, to permit of a vertical adjustment of the entire box to bring them in line one with another; *f* is an oil dish to catch the drippings from the box. It is quite evident that a shaft placed in such a bearing will control the positions of the box, and will press uniformly over the entire length of the box.

Plungers.

Oil dish.

This is a very important feature, as can be seen when compared with a rigid bearing. When hangers, having their boxes or bearings made in one piece with the hanger, are to be attached to beams, some distance from each other, they must be bolted securely to the beams in such positions as will insure all the boxes in the entire series being in line one with another, so that a shaft placed in the boxes will rotate freely without binding. It will readily be seen that to do this the foot of the hanger must be carefully fitted to the beam, so that a line stretched through the various boxes will touch all parts of each. This involves great skill and much time in putting up. This skill and time is at the cost of the purchaser and user of the hanger.

Trouble of setting rigid hangers.

Increase of cost to user.

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Then when they are in place, the warping or twisting or sinking down of any one beam will throw the bearing out of line, and thus tend to cramp the shaft in its bearings. With the ball and socket hanger, care is only required to bring the hangers in line sideways; the plungers admit of adjustment vertically, and the shafts twist the box into line with itself. Thus all skilled labor is dispensed with in putting up, and possible adjustment is at all times practical.

Ease of putting up ball and socket hangers.

But the most important feature of this hanger is the possibility of using longer bearings or boxes than with the rigid hanger. With the latter, the longer the box the more difficult to line, and the more useless friction if out of line. With the swiveling principle, the box adjusts itself, and thus takes a uniform bearing over its entire length. This is of the greatest importance, and influences the material forming the box. With a pressure not exceeding fifty pounds per square inch, and oil well distributed over the surface of the box, the metal of the shaft will not touch the surface of the box; it will run on the oil used as a lubricator. The oil under this pressure is not squeezed out, and maintains its lubricating properties for a long time. Hence, if the shaft does not touch the box, it matters little what metal is used in making the box. Cast iron is the cheapest and most readily worked into shape. It is, in reality, the most durable of the metals for the purpose if kept well oiled, but the poorest if allowed to run dry. Brass or bronze has been used to a great extent, and lately a metal called Babbitt's metal has met with favor as a lining metal for boxes; but we may mention that a cast iron nut on a lead screw of a lathe will outwear a brass nut two to one, and cast iron gear wheels are

Pressure on the bearing.

Oil is not squeezed out

Babbitt's metal.

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much more durable than brass under limited pressure; that is, if the pressure on two pairs of wheels, one pair iron and one pair brass, be the same, and the pressure on both be within the limit at which cast iron will run without breaking, the cast iron wheels will last much the longest. Brass is resorted to for greater toughness, not for durability. The soft metals, under the general term of Babbitt's metal, are cast into recesses in journal bearings, and are extensively used. There are places where its use is advantageous, but for shafting purposes its use is to be discouraged. All soft metals, while they do not cut when permitted to run dry, in the way cast iron is sure to do, yet they serve to catch the grit and dirt in the atmosphere which finds its way in with the oil, and the soft metal holds these little sharp particles, and thus gradually grinds down the shaft running in it. When it is desired to grind down a cylinder of hard metal, lead clamps are applied to its surface very like journal boxes, and into these clamps oil and emery is fed. The lead will hold the emery, and thus reduce the size of the hard metal without serious wear on its own part. It is claimed that boxes cast with a recess to hold the soft metal can be used as they come from the foundry, and thus all labor of boring and fitting be dispensed with; the shaft can be laid in place on the cast iron shell, and soft metal, melted in a ladle, can be poured in, thus filling the recess and insuring a fit. This sounds very plausible; but the box with its recess must be rather larger, to be of equal strength, with one cast without such recess. Babbitt's metal costs much more than cast iron; we may safely say it costs ten times as much. The melting and pouring takes time, which costs money. Now, in point of

Soft metal linings hold grit.

Comparison of cost of soft metal bearing.

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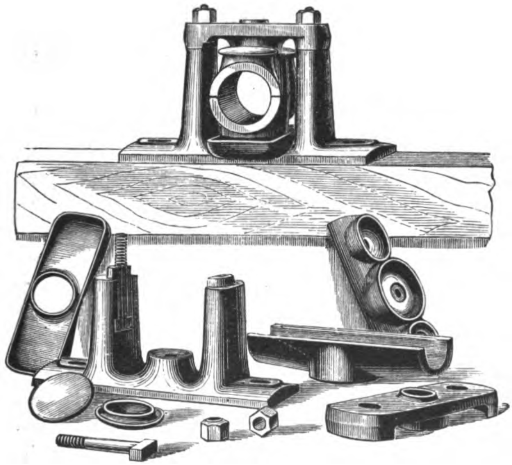
fact, a pair of cast iron boxes can be planed on their faces, then bored to fit the shaft, and grooved for oil passages, for less than half of what the least quantity of soft metal would cost that can be used in such a box.

What we have said in description of the modern hanger holds good in the various forms of bearing, suited to various uses, where hangers are not admissible. Thus, when the shaft is to be carried by stone piers, not likely to lose their horizontal adjustment, or in case of vertical shaft, pillow blocks are used in place of hangers. (See Fig. 121.) The box is furnished **Pillow blocks.**

FIG. 121.



with spherical surfaces to fit in sockets in the casting or frame; it is self-adjusting as to line, but cannot be raised or lowered, as in the case of the hanger. It takes the place of what is known as the clamp box (see Fig. 122), and of any rigid bearing not adjustable. **Takes the place of clamp boxes.**

Pillow blocks are sometimes used in connection

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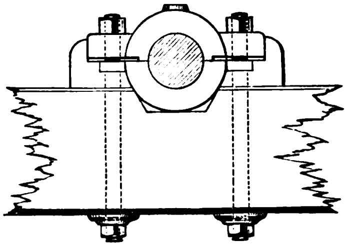
with cast iron wall plates upon which they rest, and are secured by bolts. (See Fig. 122.) This same com-

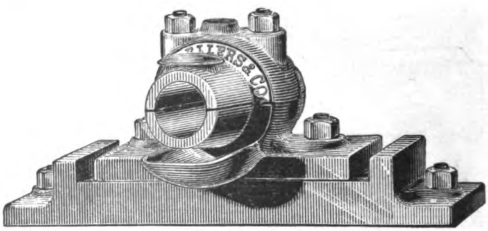
Fig. 122.



Use of pillow block on head shafts.

bination inverted, with an oil dish on the cap of the pillow block, is now sometimes used to carry the head

Fig. 123.



shaft of long lines, as it admits of the very heavy head shaft, with large pulleys, being hoisted into place and then secured by the cap and bolts. Head shafts, or the first shaft of any line, usually rest in two bear-

Inverted pillow block.

ings. Fig. 124 shows such an inverted pillow block.

Arched wall box.

Sometimes it is requisite to build bearings in a wall, in which case what is called an arched wall box (Fig. 125) is used in connection with the pillow block. Very often it is advisable to support the line shaft

Brackets for pillow blocks.

from the face of a wall, in which case pillow blocks, secured to knees, are very convenient. (Fig. 126.)

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FIG. 124.

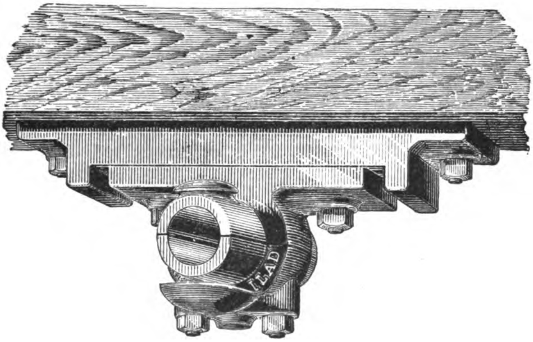


FIG. 125.

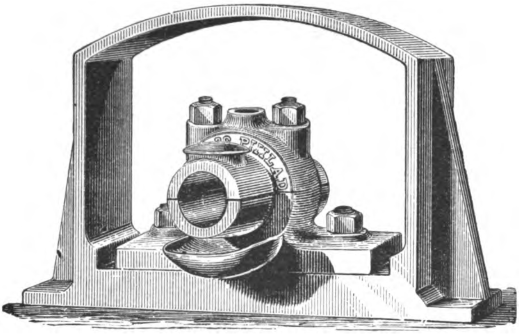
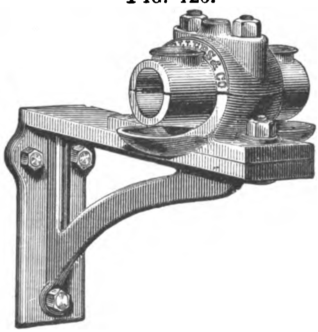


FIG. 126.



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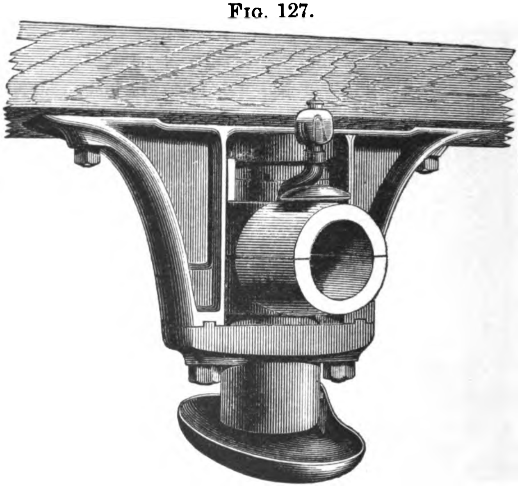
While the inverted pillow-block, as shown in Fig. 124, answers some of the requirements of a head-shaft bearing, yet it does not permit of vertical adjustment when in place on the beam or footing-piece, nor can the top half of the box be removed without lowering the entire shaft. We therefore recommend for this purpose what we term our Head-Shaft Hanger, as is shown in Fig. 127.

Head-shaft hanger.

FIG. 127.



The lower part of this hanger is attached to the frame by bolts after the manner of the cap of a pillow-block, and is tongued into the frame to add stability to the frame. The box or bearing is made precisely like those in our regular line hangers, and is held in place by screwed plungers, as in the hangers. These plungers permit a limited amount of adjustment, and thus greatly facilitate the erection of the work, and the lining up of the shafts if the building to which it is attached settles unequally. One of the principal

Bottom of hanger takes off.

Adjustment of hanger.

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advantages offered by this form of hanger, apart from the ready placing of the head-shaft with its pulleys in position from below, is that the top half of the box can be removed, if necessary, without disturbing any of the adjustments. This facility of getting at the bearing while the shaft is running is of great importance, particularly if the box becomes heated by reason of too great belt-strain on the pulleys, or from neglect in oiling. The top half of the box being removed, appliances can be resorted to to cool the heated journal or otherwise correct the evil.

Removal of top box.

We deem it of the utmost importance that oil should be fed to the centre of all journal bearings. It is not sufficient to oil a long box at two places, one near each end. The oil should be fed into the centre of the top box. With this in view we arrange a projecting arm, seen in the cut, Fig. 127, to carry the glass oiler, and thus bring it outside of the beam to which the hanger is attached. In this form of head-shaft we also have accomplished the desirable result of obtaining an adjustable hanger of short drop for large sizes of shaft, our 6″ hanger being of 11-inch drop, thus working in well with the line hanger, which in cotton and woolen mills are generally made of 11-inch drop, or eleven inches from the centre of the shaft to the base of the hanger where it is attached to the beam.

Oil fed to centre of box.

Drop of hanger.

In case it is required to work in with hangers of deeper drop, it can be readily blocked down with a wooden footing-piece, or attached to an iron bed-plate, if such an arrangement is deemed preferable. The oil dish below the hanger is loose and can be removed to empty, it being attached to the hanger by a single pin.

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FIG. 128.

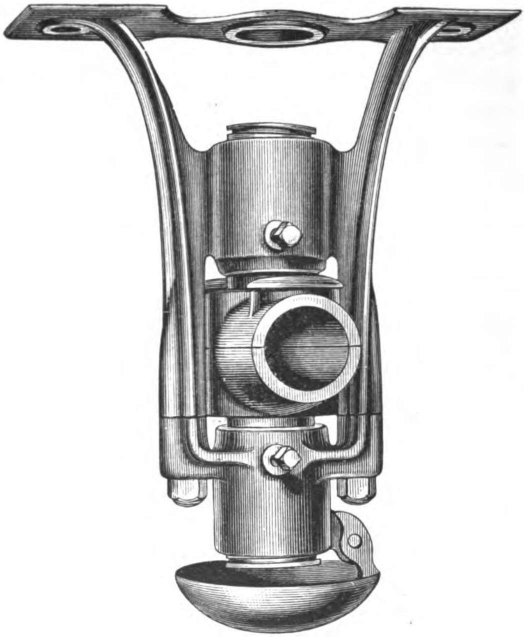

Fig. 128 shows a form of hanger similar to our regular line hangers, with open end, called OPEN END LINE HANGERS. These are lighter than our regular head-shaft hanger, and serve the same purpose where applicable.

Using hanger as a pillow block.

Besides using these open-ended hangers as head-shaft hangers, or in any part of the line where they are more convenient than the closed hanger, we frequently use them inverted as pillow blocks. In the case of some of the lines in Grain Elevators, we plane the foot and fit it to one of our regular plain wall plates, and so obtain a side adjustment of the line, the vertical ad-

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justment being supplied by the plungers of the hanger itself. This has proved a very excellent arrangement for the case specified, of Grain Elevators, as the varying load in buildings used for storing grain make possible adjustment of the line very necessary. When hangers are inverted and used as pillow blocks we make an oil dish with boss, which fits in the hole shown in the foot of the hanger.

Oil dish when hanger is inverted.

One of our recent improvements in pillow blocks, shown in Fig. 121, is the separation of the oil dish from the main casting, permitting the block to be used upright or inverted, by the mere shifting of the boxes and the oil dish.

This is a very important matter, as pillow blocks carried in stock can be used in either direction of base; that is to say, sitting on a beam or suspended below the beam.

We also make a form of pillow block especially adapted for supporting the line shafting used to drive sewing-machines. This bearing, which we call a pedestal pillow block, resembles the upper portion of an ordinary pillow block, carried on the end of a plunger, working through a bearing in a stand which is bolted to the floor, and is secured at the height desired by a set screw. It is so arranged that the height of the line above the floor may be varied a distance of several inches.

Lag or wood screws.

In the erection of shafting we recommend the use of wood screws, which are made with a nut on one end, the other with the coarse screw common to wood screws. These screws, once in place in the wood, need not be disturbed in taking down or in putting up the hanger, the removable nut holding the hanger to place.

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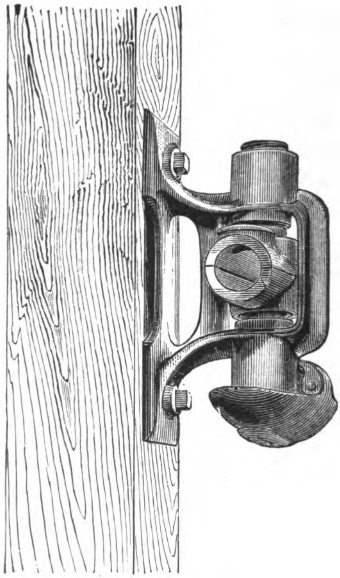
Post hanger.

Fig. 129 shows an example of a hanger to be fitted to a post; it is called in that form a post hanger. It is, in all essential particulars, like the ordinary hanger, so far as its adjustment and swiveling principles are concerned.

FIG. 129.



Durability of cast iron bearings.

As an illustration of the durability of cast iron bearings for shafting purposes, we may mention that some time since we took occasion to examine a bearing in which had been running, for sixteen years, a 4½-inch shaft, with a pulley 72 inches diameter and 20 inches face, close to the bearing, taking all the power from an engine of 16-inch cylinder, 3-foot stroke, making 50 strokes per minute,—say transmitting fifty-two horse-

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power. This bearing showed a bright surface over the extent of one-third of the circumference of the shaft on the bottom half box. The box had been originally made to fit the journal loosely, and it had not worn enough to make it fit over one-third of the circumference of the shaft. In the use of cast iron bearings, lubrication must be attended to, else the bearing will soon be cut and rendered useless; but lubrication is so easy, and so little oil is needed for the purpose, that there can be no reasonable excuse for neglect. We provide every box with large cavities in each end of the top box; these cavities are called tallow cups. They should be filled with tallow and oil, mixed so as to be of such a consistency as not to be fluid in warm weather. Should the journal heat from any cause, this same solid lubricant will melt, and, running into the bearing, will protect it for the time being. The box should be oiled in the centre; and oil holes are provided for that purpose in the recess around the spherical portion of the top box. There is also a hole in the very centre of the ball on top, and the top plungers, which rest on the ball, being hollow, a self-feeding oil cup can be placed on top, and thus deliver oil regularly to the bearing. As to the quantity of the oil needed, we would remark that shafts running in self-adjusting hangers, with bearings four diameters long, at a speed of 120 revolutions per minute, require, on an average, $2\frac{2}{10}$ fluidounces of oil per bearing for six months' oiling; and self-feeding oilers, placed on top, should not deliver any more than this quantity.

Lubrication.

Tallow cups.

Quantity of oil required.

From time to time a great deal is said about self-oiling boxes. By this term are meant boxes that are made to contain oil in some reservoir, usually under

Self-oiling boxes.

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the shaft, and from which reservoir oil is fed to the shaft, and then allowed to run back into the reservoir and thus be used over and over again. It is said that bearings in self-oiling boxes have been made to run for a year or more without attention; but we have never known a self-oiling box to be made to work well with so little oil as $4\frac{4}{10}$ fluidounces in it. Some of them hold a pint each. One pint is 16 fluidounces, quite enough oil to last four years, if properly applied; and yet it would never do to trust that quantity of oil for that time, as it would become deteriorated by age. Self-oiling boxes are rather more costly, and take more oil to run them, than properly made bearings oiled by hand. Self-oiling boxes are good things to sell,—better than to use; they are good things to talk about to those who do not know what true economy in oiling

Glass oil cups.

is. Glass oil cups above the bearing, feeding oil at such a rate as to consume $2\frac{1}{4}$ fluidounces in six months, to say hangers for $2\frac{1}{2}$ shafts, are the best, and oil fed at this rate will not run out of the box ends, but will just supply the waste from consumption.

Collars.

All shafts, long or short, must be provided with some means of preventing end motion. Line shafts should have one pair of collars fitted to one of the bearings only. We recommend them to be placed on the head shaft,—that is, on the largest shaft which receives the power,—and thus control the position of the entire line; more collars are apt to cause needless friction. When shafts are collared, the collars should be fast to

Loose collars.

the shaft; loose collars held in place by set screws are sometimes used, but are more expensive and cumbersome than the fixed or fast collars. Some engineers prefer necking in the head shaft to some smaller size in the journals. Suppose the first or head shaft re-

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quires to be made of iron 6½ inches diameter, to sustain the driving belt. This shaft might be necked in, and be carried by bearings say 5½ inches diameter, and the ends still further reduced to the size of the shaft to be coupled to it. This practice of necking in the bearings of the head shaft is common in modern cotton-mill practice, and has the advantage of diminishing the velocity of the surface motion and of the shaft in the box; for by diminishing the diameter we diminish the speed of the rubbing parts, and the tendency to heat is much increased with increase of velocity.

Necking in of shafts.

To determine the size of shafts for the transmission of a given power, a safe formula is $D = \sqrt[3]{\frac{P}{R} \times 125}$, D being diameter of shaft, P the horse-power, and R the number of revolutions per minute. This gives a shaft strong enough to resist flexure, if the bearings are not too far apart. The distance apart that the bearings should be placed is an important consideration. Modern millwrights differ slightly in opinion in this respect: some construct their mills with beams 9 feet 6 inches apart, and put one hanger under each of the beams; others say 8 feet apart gives a better result. We are clearly of opinion that with 8 feet distance, and shafting lighter in proportion, the best result is obtained. The tendency now is to increase rather than diminish the speed of line shafts; and good practice is to run shafts for machine-shop purpose at 120 revolutions, for wood-working machinery at 250 revolutions, and for cotton and woolen mills at from 300 to 400 revolutions per minute. Hollow or pipe shafting has been made to run at 600 revolutions per minute very satisfactorily. This kind of shafting is, however, too costly to be generally introduced.

Formula for size of shaft.

Distance apart of hangers.

Speeds.

Mr. James B. Francis, of Lowell, says that since the

Mr. James B. Francis.

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decrease of the water-power in that town, or rather the rapid increase of the factories, they have been obliged to economize their power, and they are doing so by using smaller shafts at higher velocities, and have even made extended lines only $1\frac{1}{4}$ inch in diameter. They so arrange the mill as to secure a hanger close to each transmitting pulley. The torsion in long lines limits the smallness of the shaft used, and in all probability the best result will be found to be obtained in the use of not less than $1\frac{3}{4}$-inch diameter for the smallest line shafts in cotton mills.

There are now running in some factories lines of shafting 1000 feet long each. The power is generally applied to the shaft in the centre of the mill, and the line extended each way from this. The head shaft being, say 5 inches diameter, the shafts extending each way are made smaller in proportion to the rate of distribution, so that from 5 inches they often taper down to $1\frac{3}{4}$. In coupling shafts of different sizes it is customary to reduce the end of the larger one to the size of the smaller shaft, and then to use a coupling suited to the smaller size.

Coupling shafts of different sizes.

FIG. 130.

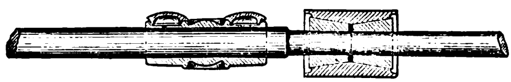

Fig. 130 shows an example of this method of reducing the larger shaft to the size of the smaller one. The rapidity with which the reduction of the size of the sections is made must depend, in all cases, on the distribution of the power. For instance, if a line of any length whatever receives its power at one end and transmits the same amount of power at its other end,

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such shaft must be of uniform diameter; but if it distributes its power at regular intervals along its length, the shaft may be made in sections of a size proportioned to the power given off.

Disadvantage of too small shafts.

When very long lines of shafting are constructed of small or comparatively small diameter, such lines are liable to some irregularities in speed, owing to the torsion or twisting of the shaft as power is taken from it in more or less irregular manner. Shafts driving looms may at one time be under the strain of driving all the looms belted from them, but as some looms are stopped the strain on the shaft becomes relaxed, and the torsional strain drives some part of the line ahead, and again retards it when the looms are started up. This irregularity is in some cases a matter of serious consideration, as in the instance of driving weaving-machinery. The looms are provided with delicate stop motion, whereby the breaking of a thread knocks off the belt shifter and stops the loom. An irregular driving motion is apt to cause the looms to knock off, as it is called, and hence the stopping of one or more may cause others near to them to stop also. This may in a measure be arrested by providing fly-wheels at intervals on the line shaft, so heavy in their rim as to act as a constant retardant and storer of power, which power is given back upon any reaction on the shaft, and thus the strain is equalized. We mention this, as at the present time it is occupying the thoughts of prominent millwrights, and the relative advantage and disadvantage of light and heavy shafts is being discussed, and is influencing the practice of modern mill construction.

Fly-wheels on line.

Transmission of motion by belts.

In a system of transmission by belts only, it is of importance that both the belts and the pulleys, or

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band wheels upon which they run, should be in the best possible condition.

Leather belts. The best belts used are of leather, kept in good condition by the judicious use of oil. Belts of leather are made of single thickness of leather for some purposes, and of two or more thicknesses for the endurance of heavier strains. In general, main driving belts are made double thickness, and belts for transmission of power to machines, with some exceptions, are made single thickness. The terms double and single belts have come to be applied to leather bands in the trade, while india-rubber belts, now quite extensively used, and often to advantage, have their grades indicated by one-ply, two-ply, three-ply, etc., as indicating their thickness. It is of the utmost importance, for considerations of economy in running, as well as first cost, that pulleys should be made as light as is consistent with strength. Pulleys that are to sustain the weight of double belts must be made heavier and stronger than those that are to sustain the weight of single belts; and the use to which the pulley is to be applied must influence its proportions. In the early practice of making cast iron pulleys it was believed necessary that the arms should be made something like the letter *S* on the plane of the pulley. The idea was that they would be less likely to break from shrinking strains in the casting. It is quite evident, however, that a straight arm, such as is shown in Fig. 131, representing a straight line from the centre to the circumference, will take the least metal; and we can state as a fact, after very long experience, that pulleys made with straight arms are the strongest, with equal proportions, provided proper precaution be taken in selecting the iron to be used in making and

India-rubber belts.

Pulleys for double belts.

Straight arm.

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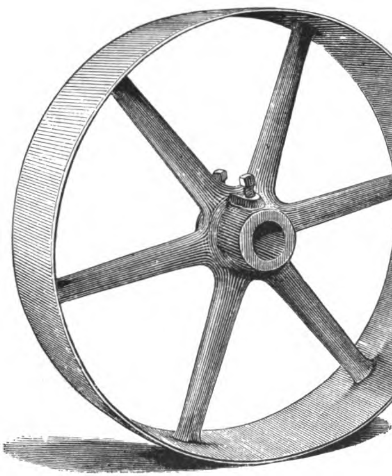
regulating the conditions of cooling. The straight-armed pulley can be made with the least possible

Fig. 131.



metal and the greatest possible strength for the metal. Its form is the best able to transmit the peculiar strains brought to bear upon it, and at the same time it is the most pleasing form to the eye. In machinery, as in nature, fitness to intended purposes has much to do with our ideas of beauty.

We make the arms oval, of such proportion as to present the least surface of resistance to the air in running, and as light as is consistent with strength. We are fitted with patterns varying in diameter by ¼ inch up to 12 inches diameter, by ½ inch up to 20 inches diameter, by 1 inch up to 30 inches diameter, and by 2 inches up to 72 inches diameter. Of these various sizes we make varying widths of face, the **Sizes of pulleys**

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arms in all cases being proportioned to the work the pulley is expected to do. Thus, for single belts which do not shift upon the pulley we make the pulleys "high" or crowning in the centre of the face, and with rims and arms of adequate strength; if for a double belt, the rims and arms are made stronger in proportion. If for a shifting belt, as are the pulleys on line shaft, which lead on to fast and loose pulleys on the counters, the faces are made straight, and the arms are adapted to the belt intended to be used on the pulley. This may be thought to be a needless refinement; but it affects the cost. If such a system were not adopted, all pulleys would require to be made strong enough for the heaviest work, and those wishing them for light work would have to pay the price of the heaviest; whereas by our system we not only are enabled to sell pulleys at prices varying with their requirements, but such pulleys, when in place, do not contain any superfluous metal to weigh down the shaft and add to the cost of running it.

Single belts high.

Straight face.

Light pulleys.

We should in all cases know what kind of belt is to be used on the pulley; but we should also know the speed at which the pulley is to run, as we carefully balance all our pulleys to run without shaking at the required speed. Small pulleys are bored to a size that allows them to slide over the shaft loose and be held by set screws. We so arrange the boring and turning that the pulleys so held run true when fastened by the set screws. Pulleys over 36 inches diameter, 4 inches face, should in all cases be held by keys; if required to be a loose fit, with key and set screws combined. In this case the key seat is straight, not taper; the key must be let into the shaft, the pulley pushed over it, and held in place by the set screws.

Pulleys held by set screws.

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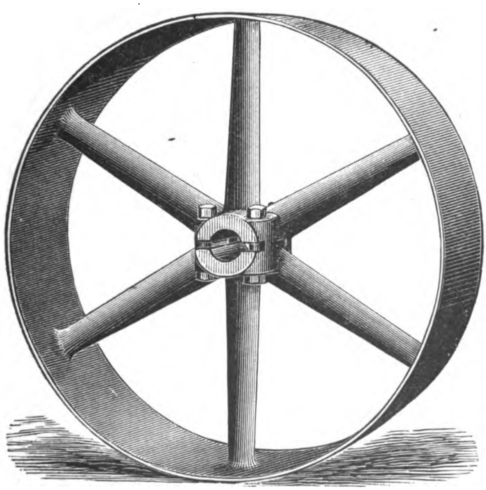
It must, however, be borne in mind that pulleys held in the manner just stated cannot be depended on if required to do much work. The fit is loose, and during part of each revolution the bearing is only on the points of the set screws. The introduction of what we call our clamp-hub pulley, which we used in connection with some of our machine tools many years ago, before applying it to line pulleys, fills the require ment of a secure method of holding pulleys submitted to much strain, and entirely does away with the necessity of making forcing fits for main driving pulleys, which is the usual alternative when the parted hub is not made use of. Fig. 132 shows what we call our

FIG. 132.



clamp hub pulley. It will be seen that the hub is split and drawn together by bolts, but the rim of the pulley is not parted. We bore these pulleys small for

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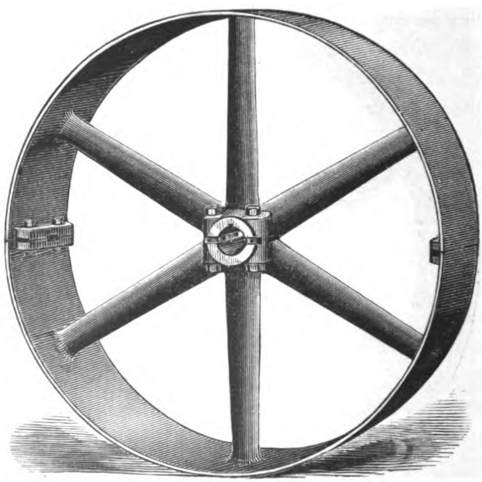
the shaft, as much so as if for a forcing fit, then wedge the split open to slide the pulley on to the shaft, withdrawing the wedges when it is in place and tightening up by the hub bolts. Previous to the introduction of this form of hub as applicable to large driving pulleys we recommended the careful fitting of the pulley to place as follows. In case of large driving pulleys, such as those that receive the belt from engine, we advised that fits should be made on the shaft with the same care as is used in putting on a plate coupling; *i.e.* when we were given the position of the pulley on the shaft, we left a "fit" part of the shaft

Fig. 133.



larger than the balance of the shaft, and bored the pulley so as to require forcing on with screw press. The advantage of holding the large pulley in this manner is so great that no consideration of false

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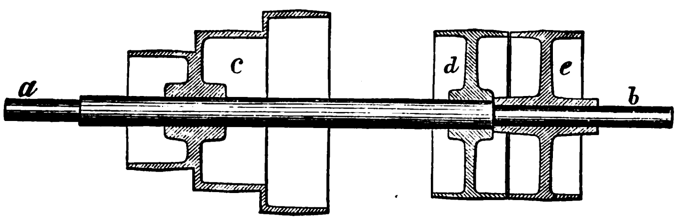
economy, or fear of trouble in getting the work put in place, should deter the user from having this part of the work carefully done, if he cannot obtain the cheaper method of hub clamping. Frequently it is not convenient to remove all of the pulleys from a line section to put a new one in place, we therefore make split pulleys, as shown in Fig. 133. So also some very large main driving pulleys are made split to enable them not only to be put up more readily, but also for economy in handling on cars and during transportation. In the case of fast and loose pulleys on counter-shaft, we always make the hub of the loose pulley longer than the width of the face of the pulley, and we arrange the hubs of the fast pulley and loose pulley so that they shall meet and keep the edges of the rims apart a proper distance. We can make the loose and fast pulleys to fit the same sized shaft, but our preference is to neck down the counter-shaft at one end to journal size, and place the loose pulleys on this smaller part next to the hanger, so that the oil fed to the hanger will pass also into the hub of the

Loose pulleys.

Necking down for loose pulleys.

FIG. 134.



loose pulley, and the box of hanger will hold the loose pulley in place. Fig. 134 shows this arrangement.

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Counter hangers. As counter hangers require no vertical adjustment to keep them in line, we make the box to swivel on a ball joint, in the same manner as in line hanger, but

Fig. 135.

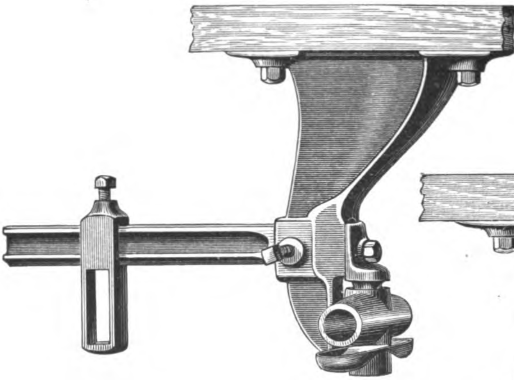
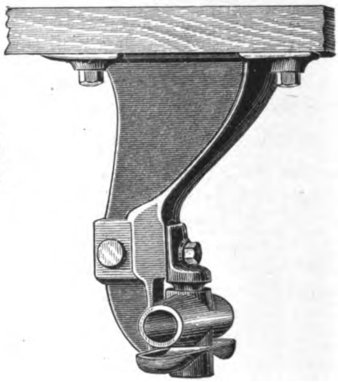


Fig. 136.



held by a cap only, with a reversible oil dish under the box, and, when required, belt-shifter arms and guides for the belt-shifter rod, as shown in Figs. 135 and 136.

Belt-shifter arms. The reversible oil dish permits the use of this hanger as a pillow block, allowing counter-shafts to be carried on the hangers acting as stands on the floor. Long lines of shafts, driving sewing-machines, are frequently erected on these hangers, reversed in the manner as above.

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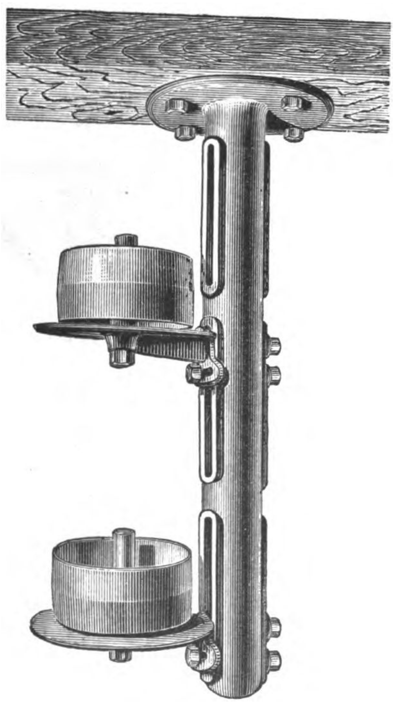
In substituting belts for gear wheels in the transmission of motion, it must be borne in mind that all possible contingencies of position of shafts one to the other, whether parallel or at any angle, can be more readily met by belts and pulleys, even up to belts 24 inches wide, than with gearing, and in a much more

Turning corners with belts.

FIG. 137.



satisfactory manner. To meet some of the cases which most frequently occur, for belts of 10 inches and under we arrange "mule pulley stands" (Fig. 137) for

Mule pulleys.

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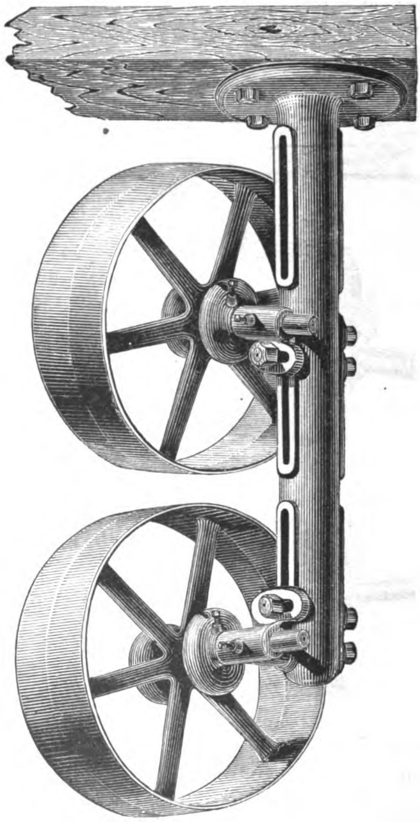
the transmission of motion to shafts on the same plane or nearly so, and at any required angle to each other.

FIG. 138.



Where the same thing is to be accomplished with the shafts on very different planes, we furnish the "binder frame" (Fig. 138) for cases requiring from

Large binder frame.

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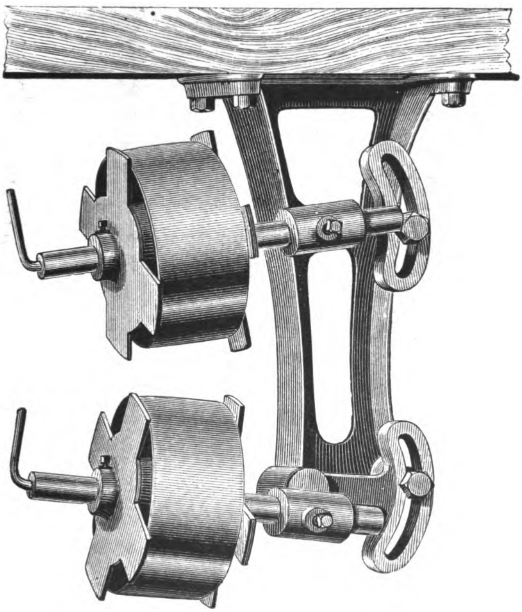
4-inch to 10-inch belts; while for the transmission of power to machines at right angle to line, where the amount of power is not great, say for 3-inch belts, we furnish a smaller "binder frame" (Fig. 139,) admirably adapted to this purpose. This last is largely

Small binder frames.

Fig. 139.



used in transmitting from lines to spinning frames which set at right angles to the line: the fast and loose pulleys being on the machine, these frames take the place of counter-shafts.

Where special arrangements are required for the transmission of a large amount of power to shafts at any angle to each other, we have various devices

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applicable to such cases that can be furnished. With us, all that pertains to mill gearing and shafting has been reduced to a systematic manufacture. To make a machine is one thing; to manufacture machines is quite another thing. Thus, one sewing machine may be made by itself at a cost more or less in proportion to the labor expended upon it. But the same machine, by means of organized labor, can be produced in quantities for a tenth of the cost of one machine. Hence systematized manufacture is needed to insure cheap productions. Our hanger and coupling would, indeed, have been expensive luxuries if simply made one at a time, with no special tools fitted to their production; but with such special tools, thorough organization of the labor employed, and the production of immense numbers of them, with all parts made to gauges, and interchangeable, the cost is less now than what the commonest rigid bearing hangers and plate coupling were made for formerly, and their adoption is now universal. Apart from systematized labor, an important item in first cost is weight of material. Not very many years ago, all shafting, and all pulleys, and everything relating to the machine for transmitting motion, were made and sold by the pound. Purchasers were attracted to the makers who charged the least per pound, and no very great care was taken to see that too many pounds did not go into the various parts of the machine. Shafts of a given size could not be made to weigh more or less by different makers; but much needless weight might be put into hangers, into couplings, and into pulleys, so that the price per pound really came to have no meaning, so far as total cost was concerned.

System of uniform gauge.

Shafting sold by the pound.

In 1856, feeling that this system of selling hangers,

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pulleys, couplings, etc., by the pound, was not the proper way to dispose of such things, we determined on a radical change; we instituted an extensive series of experiments to demonstrate just how strong, and consequently how heavy, each article comprised under this head should be. We found that pulleys might be reduced in weight, and, by the employment of suitable machinery, be more perfectly made; so of hangers, and all that pertains to shafting, except the shafts. We then published a price list, offering to sell each item at some certain fixed price, dependent upon its own cost. The price list enables the purchaser to know beforehand just how much money will be required to obtain what he wants, and for strength and durability he must take the judgment of the makers. There was great opposition to this system from those who were still anxious to sell by the pound; but in time the manifest advantages of the plan caused its adoption by other makers.

Fixed scale of prices.

All conceivable wants of the trade are met by specially contrived devices, which can be made in quantities and kept in stock ready for sale. Hangers varying in size and "drop" (*i.e.* in distance from centre of shaft to the foot) are made from carefully designed patterns. Pulleys fitted for double or single belts, for wide or narrow belts, and made high or straight on the face, are all from patterns nicely adapted to the work each has to do. Last, but not least, all these things are made to standard gauges, so as to have their parts interchangeable. In regard to the sizes mentioned, in speaking of shafts, they are called always from the size of the bar iron from which they are made, and the term "shafting size" has come to have a significant meaning. All turned shafts are

Size of shafts.

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made from merchantable sizes of round bar iron, and in turning, one-sixteenth is taken off in diameter, so that what is called a 2-inch shaft is really only one and fifteen-sixteenths in diameter, and so of other sizes; they are all one-sixteenth less than their name implies; and the couplings, hangers, etc., are made to conform to these sizes.

Table for laying out shafting.

To aid in arranging the couplings in proper relation to the hangers, as also to furnish a ready method of determining the length of each shaft on a line, with a view to ordering the same, we have prepared a "table for laying out shafting," which we give facing this page. In this table will be found, in the columns at the right-hand side, the length of the boxes or bearings, and the length and diameter of our double cone-vice couplings. Examples are given, at head of table, of a line of shafts extended in both directions from the first or head shaft, and of a line extended in one direction only. The first example is of what is usually denominated a collared shaft coupled at both ends; the other, of a collared shaft coupled at one end only. Lines of shafting laid out according to this table will present each coupling the same distance from the end of the box nearest to it, regardless of the size of the shaft.

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WILLIAM SELLERS & CO.'S

PATENT INJECTORS

FOR

FEEDING BOILERS.

REVISED 1883.

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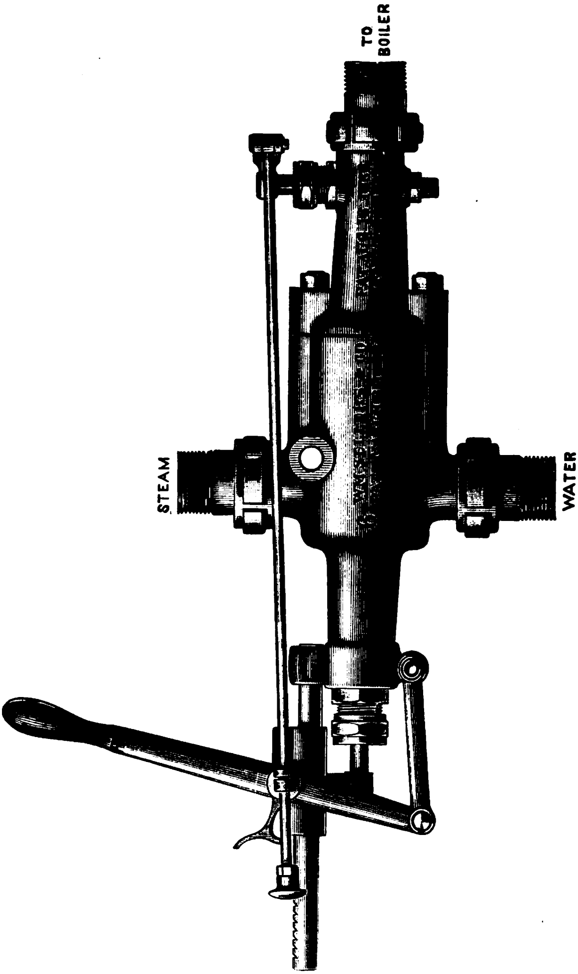
Fig. 140.



INJECTOR OF 1876.

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PATENT INJECTORS FOR FEEDING BOILERS.

(*For Report of Judges, see page* xxiii.)

A VERY thorough test of our injectors, recently made by the Park Benjamin Scientific Expert Office, of New York, shows the marked advantage of our Injector of 1876 over any other form of instrument yet introduced. We give this report entire (pp. 363 to 375). Since the introduction of this form of continuous self-adjusting boiler-feeder, we have made other simpler, and therefore cheaper styles, of injectors not self-adjusting, suited to the two conditions of lifting and non-lifting the water-supply. These have also been tested by the same experts, and the report on these (given entire, pp. 375 to 385) indicates great improvement over any other non-automatic injector. We confidently recommend these new instruments as superior to any of the instruments in the market which are not self-adjusting, for use on stationary boilers. It is our purpose in this publication to explain these, as well as give the conditions which will guide purchasers in selecting from the various forms of instruments made by us.

Cheaper forms.

False impression regarding the injector.

The impression made on most persons when the Giffard Injector was first introduced, that its theory of operation was incomprehensible, and its practical working involved nice adjustment of parts liable to be easily impaired, was only removed when use and familiarity with the invention had given confidence.

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Our construction of the instrument, of such a form as to admit of its being readily opened for inspection, tended more than anything else to bring about this end.

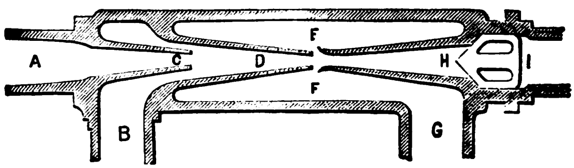
Opinion of M. Ch. Combes.

Its extended use has demonstrated the correctness of the statement made by M. Ch. Combes, Inspector-General and Director of the School of Mines, France, who, speaking of the injector for feeding boilers, soon after its introduction, said, "It is without doubt the best of all those hitherto used for feeding boilers, and the best that can be employed, as it is the most ingenious and simple, . . . and is theoretically perfect."

Simplest form of injector.

The injector in its simplest form (all details of construction being intentionally omitted) is shown in Fig. 141. It consists of a pipe, *A*, for the admission of steam, which, escaping through the nozzle *C* at a high velocity, is joined by water, which, flowing in through

FIG. 141.



the pipe *B*, and passing around the end of nozzle *C*, mingles with and condenses the steam in the conical pipe *D*, and is driven through the pipe *H* and check-valve *I* into the boiler; excess of steam or water, from want of adjustment, escaping by the outlet *F F* and pipe *G*.

Names of parts of injector.

The parts shown are common to all forms of injectors, under various shapes and modifications, and have been named: *C*, receiving-tube or steam nozzle; *D*,

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combining-tube; *H*, delivery-tube; *I*, check-valve; *F F*, overflow; and *G*, overflow nozzle. During the passage of the water from *D* to *H*, it is driven across the space *F*, and if too much water is being supplied to the steam, some water may escape at this point and flow out through the overflow nozzle *G;* while if there be too little water, air will be drawn in at *G* and carried into the boiler with the water.

An injector can be made substantially as shown, and its various parts so proportioned as to yield a good result. Such an instrument is known as a "fixed nozzle injector."

Fixed nozzle injector.

The Giffard Injector was an adjustable nozzle injector,—adjustable in both the water and steam-supply within the instrument itself. With this instrument any change in steam-supply required a corresponding change in the water-supply, and if the proper relation between these parts was not maintained there was either a waste of water from the overflow or an indraught of air at this place. So that if after an adjustment of the parts to produce the best results the steam-pressure of the boiler changed, the instrument would work badly until readjusted to the new condition. This led to the introduction of the self-adjusting injector, which is so arranged as to have no waste at the overflow; the steam being adjusted by hand, the instrument itself adjusts the water-supply. Thus, when the injector is in operation, any change in boiler-pressure makes a corresponding change in the water-flow to the combining-tube, and as a result the steam is always combined with the exact quantity of water necessary to produce the best result, with neither waste nor indraught of air. This instrument, the self-adjusting injector, since its first introduction in

Adjustable nozzle injector.

Proper relation of the parts must be kept up by hand adjustment.

Self adjusting injector. **See pages 408 and 409.**

Adjusts its own water-supply.

Self-adjusting instrument the highest type.

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1865, has from time to time been improved until the new style, the "INJECTOR of 1876," was produced. This form of the instrument was designed with especial reference to its use on locomotives, but it has proved to be so much more convenient for all purposes that it is now recommended in preference to any other of our many styles of injectors. The description of it will explain the fundamental principles of all our previous types of this instrument so far as the self-adjustment is concerned; the new injector, however, has embodied in it a device for starting which does away with the expensive valves and fittings required with our old self-adjusting injectors. Added to this, it is operated by a simple lever-motion which starts, stops, or regulates its quantity of delivery with a readiness and accuracy never before attained. The exterior view on page 358 shows the instrument in its improved form.

Injector of 1876.

Has starting-valves in the injector.

Lever to start.

During March of 1879 we were asked by the editor of *Appleton's Cyclopædia of Applied Mechanics* to permit a series of injector trials, with a view to the publication of the result of such test in that book. We accepted the proposition, and during May, 1879, the *Park Benjamin Scientific Expert Office*, of New York, undertook the tests, Mr. Richard H. Buel, C.E., being placed in charge.

Test of injectors.

The tests were made, submitting the injectors to the *most thorough* trials that could be devised in order to cover all conditions occurring in practice. These experiments were probably the most important and extended ever made. The report submitted by the Expert Office so thoroughly covers the explanation of the instruments, as well as the results attained, that we now publish it entire as it appears in the pages of the Cyclopædia.

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"THE SELLERS INJECTORS.—*Report of Tests conducted by Park Benjamin's Scientific Expert Office, May,* 1879, *at the Works of Messrs. W. Sellers & Co., Philadelphia. Trials in charge of Richard H. Buel, C.E.*

"*Preparations and Conditions.*—The supply-water for the injectors was delivered through a pipe in such a manner that it could be run into a tank elevated above the level of the injector, into a tank below this level, or could be admitted directly to the injector under the pressure in the main, as desired. It could also be drawn directly from the pipe or through a Worthington water-meter. Both the supply and delivery pipes connected with the injector were provided with cups through which water was allowed to escape from these pipes, and in which a thermometer could be placed for the purpose of ascertaining the temperature of the feed and delivery water. The steam-supply pipe leading to the injector was provided with a throttle-valve, for the purpose of reducing the steam-pressure when desired; and a sensitive pressure-gauge was connected to the steam-pipe between the throttle-valve and the injector. This same pressure-gauge could be connected with the delivery-pipe between the injector and the check-valve of the boiler, so that it could be used to indicate the water-pressure by closing the valve in the pipe connecting the gauge with the steam-pipe, and opening the valve in the pipe connecting the gauge with the delivery-pipe. The delivery-pipe was connected directly with the feed-pipe of the boiler that supplied steam to the injector, and there was a safety-valve in the delivery-pipe (which could be loaded to any desired pressure) between the injector and the check-valve of the boiler. A large Harrison

Condition of tests.

Test of temperature.

Pressure gauges.

Delivery-pipe.

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Boiler. boiler, having 48 square feet of grate-surface, and consisting of 1088 cast-iron spheres, each 8 inches in diameter, was used to furnish steam for the experiments. The boiler was managed by an exceptionally expert fireman, who maintained the steam-pressure at any point required without sensible variation. The

Water-supply pipes. water-supply pipes were so arranged that by heating water in the elevated tank previously mentioned (which could be done by blowing live steam into the tank, or feeding hot water into the tank by the injector), cold water could be mixed with this in any desired proportion, in the pipe connecting the tank with the supply-pipe of the injector, so that the highest temperature of feed-water admissible could readily be determined.

Temperature of water.

Scaffold for high lifts.

"A scaffolding was constructed on the roof of the testing-room, and steam, supply, and delivery pipes were provided, for connecting the injector at a considerable elevation above a portable tank in the testing-room, for experiments with lifts greater than could be measured when the injector was used on the lower level. The supply-pipe for high lifts was made in sections, so that the lift could be readily varied. A sensitive chemical thermometer was used for measuring temperatures, and this was tested by being placed in boiling water and in melting ice, and found correct at these two points. The water-meter was also carefully tested by running water through it at various rates into a tank of known capacity. It was found that the readings of the meter were somewhat in excess, the results of a number of trials at various rates giving an actual delivery of 45.4 cubic feet for a delivery as indicated by meter of 46.3 cubic feet; so that the proper correction for delivery was made by

Water-meter.

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multiplying the readings of the meter, in every instance, by $\frac{45.4}{46.3} = 0.981$.

"*The Injectors.*—Three patterns of injectors were tried in these experiments, and descriptions of each, with results obtained, are appended. All the injectors had the same numerical size, No. 6, the number indicating that the smallest diameter of the delivery tube was 6 millimetres, or 0.2362 inch. This dimension was carefully measured in the case of each injector.

Size of injector tested.

"The general features of the injectors used in these experiments cover, with the exception of special details of construction, nearly all the varieties in the market; illustrating—

"1. The injector with automatic adjustment of combining-tube and water-supply, in connection with a lifting attachment;

Kinds of injector tested.

"2. The non-adjustable injector with fixed nozzles, non-lifting;

"3. The non-adjustable injector with fixed nozzles, in connection with a lifting attachment.

"These instruments have, however, some special details of construction, as will appear by the descriptions that follow.

"1. *The Self-Adjusting* 1876 *Injector.*—An elevation of this injector is shown in Fig. 142, and a sectional view in Fig. 143. The injector is self-contained; or in other words, it has both steam and check valves, so that it can be connected directly without other fittings, although of course it is generally desirable to place another stop-valve in the steam-pipe, and a check-valve in the delivery-pipe, so that the injector can be taken to pieces or disconnected at any time. Another important feature of this injector is, that it is operated by a single handle, and

Injector of 1876.

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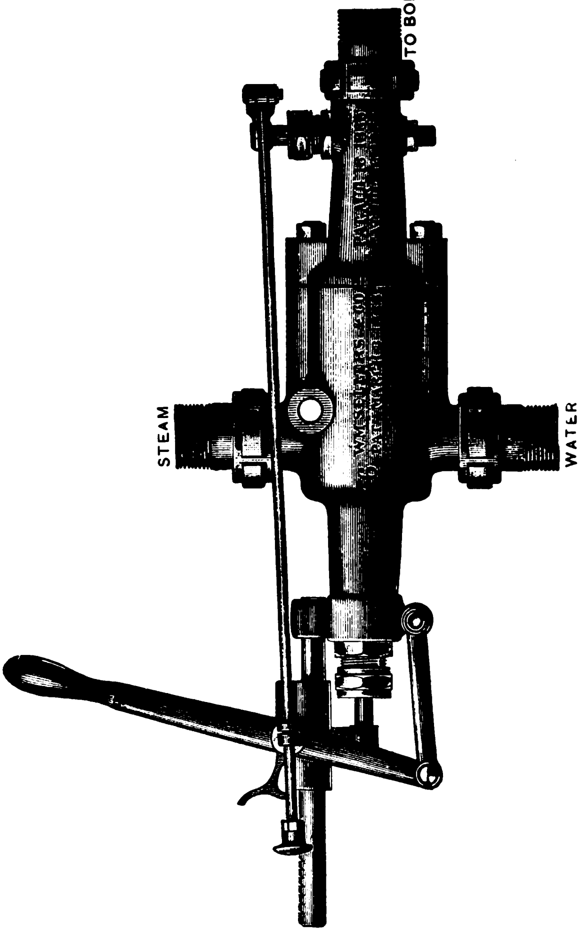
that the waste-valve is only open at the instant of starting.

FIG. 142.



Receiving-tube. "Referring to Fig. 143, *A* is the receiving-tube, which can be closed to the admission of steam by the

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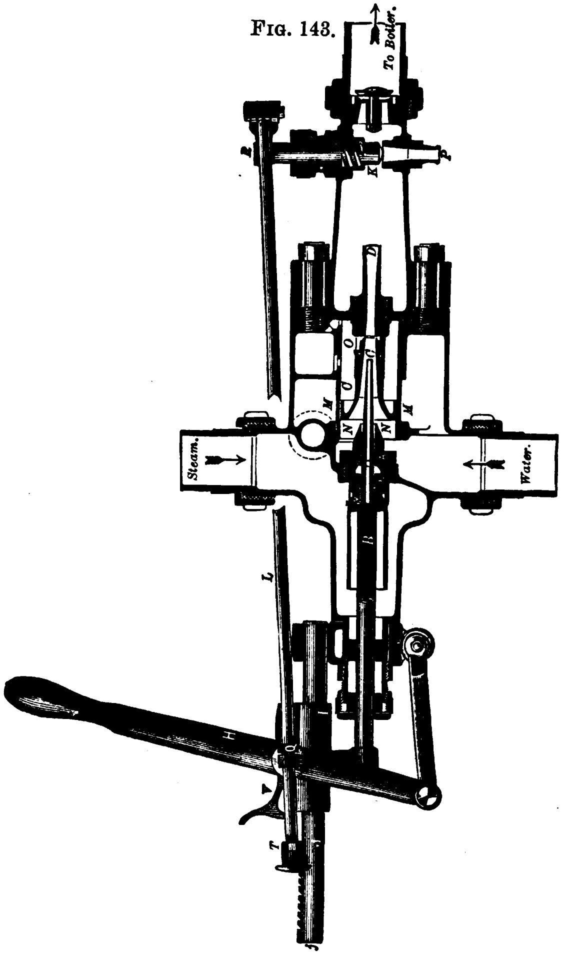
valve *X*. A hollow spindle passing through the receiv-

Fig. 143.



ing-tube into the combining-tube is secured to the rod *B*, and the valve *X* is fitted to this spindle in such a way

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Spindle and valves. that the latter can be moved a slight distance (until the stop shown in the figure engages with valve *X*) without raising the valve *X* from its seat. A second valve, *W*, secured to the rod *B*, has its seat in the upper side of the valve *X*, so that it can be opened (thus admitting steam to the centre of the spindle) without raising the valve *X* from its seat, if the rod *B* is not drawn out any farther, after the stop on the hollow spindle comes in contact with the valve *X*. *D* **Overflow opening.** is the delivery-tube, *O* an overflow opening into space *C*, *K* the check-valve in delivery-pipe, and *P R* the waste-valve. The upper end of the combining-tube has a piston, *N N*, attached to it, capable of moving freely in a cylindrical portion of the shell *M M*, and the lower end of the combining-tube slides in a cylindrical guide formed in the upper end of the delivery-tube.

Cross-head and lever. "The rod *B* is connected to a cross-head which is fitted over the guide-rod *J*, and a lever, *H*, is secured to the cross-head. A rod, *L*, attached to a lever on **Waste-valve.** the top end of the screw waste-valve passes through an eye that is secured to the lever *H;* and stops *T*, *Q* control the motion of this rod, so that the waste-valve is closed when the lever *H* has its extreme outward throw, and is opened when the lever is thrown in so as to close the steam-valve *X*, while the lever can be moved between the positions of the stops *P*, *Q* without affecting the waste-valve. A latch, *V*, is thrown into action with teeth cut in the upper side of the guide-rod *J*, when the lever *H* is drawn out to its full extent and then moved back; and this click is raised out of action as soon as it has been moved in far enough to pass the last tooth on the rod *J*. **Air chamber.** An air-vessel is arranged in the body of the instru-

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ment, as shown in the figure, for the purpose of securing a continuous jet when the injector and its connections are exposed to shocks, especially such as occur in the use of the instrument on locomotives.

Starting the injector.

"The manipulation required to start the injector is exceedingly simple,—much more so in practice, indeed, than it can be rendered in description. Moving the lever *H* until contact takes place between valve *X* and stop on hollow spindle, which can be felt by the hand upon the lever, steam is admitted to the centre of the spindle, and, expanding as it passes into the delivery-tube *D* and waste-orifice *P*, lifts the water through the supply-pipe into the combining-tube around the hollow spindle, acting after the manner of an ejector or steam-siphon. As soon as solid water issues through the waste-orifice *P*, the handle *H* may be drawn out to its full extent, opening the steam-valve *X* and closing the waste-valve, when the action of the injector will be continuous as long as steam and water are supplied to it.

Regulation of the injector.

"To regulate the amount of water delivered, it is necessary only to move in the lever *H* until the click engages any of the teeth on the rod *J*, thus diminishing the steam-supply, as the water-supply is self-regulating. If too much water is delivered, some of it will escape through *O* into *C*, and, pressing on the piston *N N*, will move the combining-tube away from the delivery-tube, thus throttling the water-supply; and if sufficient water is not admitted, a partial vacuum will be formed in *C*, and the unbalanced pressure on the upper side of the piston *N N* will move the combining-tube toward the delivery-tube, thus enlarging the orifice for the admission of water. From this it is evident that the injector, once started,

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will continue to work without any further adjustment, delivering all its water to the boiler, the waste-valve being kept shut. By placing the hand on the starting-lever it is easy to tell whether or not the injector is working; and if desired, the waste-valve can be opened momentarily by pushing the rod L, a knob on the end being provided for the purpose.

Method of deciding if injector is working.

"*Experiments with the Self-Adjusting* 1876 *Injector.*—In the experiments made with the injector described above, a No. 6 instrument was employed, selected at random from a lot in stock. It was run for considerable intervals of time at pressures varying by 10 lbs. from 10 to 150 lbs. per square inch, the manipulation described above being observed in each instance; and at all pressures the adjustment of the water-supply was perfect for all positions of the starting-lever, within the capacity of the instrument.

Test of 1876 injector.

"Table I. shows the results of the experiments on delivery of injector, temperature of delivered water, and other particulars, which are fully detailed in the general heading and in the several columns. For each pressure of steam noted in column 1, the water was delivered by the injector into the boiler under approximately the same pressure. The delivery was measured by observing the indications of a water-meter, and correcting the readings as already described, meter-readings being taken at frequent intervals, and each experiment being continued for a sufficient length of time to obtain a number of duplicate readings for equal intervals. The pressures in column 8 were obtained by throttling the steam supplied to the injector, and observing the pressure at which it ceased to work, each experiment being repeated several times with precisely the same results. The temperatures in

Delivery of the injector.

Measure by means of water-meter.

Temperature.

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column 9 were obtained by gradually heating the water supplied to the injector, and noting the temperature at which it ceased to operate, each temperature recorded being checked by several repetitions of the experiment.

TABLE I.—*Maximum and Minimum Delivery of the Self-Adjusting 1876 Injector, No. 6; Temperature of delivered Water, Pressure against which Injector delivers Water, and Highest Temperature admissible of Feed. Water flowing to Injector under 15 Inches Head. Waste-Valve shut.*

Pressure of Steam supplied to Injector, and Pressure against which Water is delivered. *Lbs. per Sq. In.*	Delivery in Cubic Feet per Hour.			Temperature, Fahrenheit Degs.			Pressure of Steam required to deliver Water against Pressure in Column 1.	Highest Temperature admissible of Feed-Water, Fahrenheit Degrees.
					Delivered Water.			
	Maximum.	Minimum.	Ratio of Minimum to Maximum Delivery.	Feed-Water.	At Maximum Delivery.	At Minimum Delivery.		
1	2	3	4	5	6	7	8	9
10	75.3	63.6	0.845	66	100	94	3	132
20	82.4	61 2	0.743	66	108	104	9	134
30	94.2	56.5	0.600	66	114	116	16	134
40	100.1	60.0	0.599	66	120	123	22	132
50	108.3	64.7	0.597	66	124	125	27	131
60	116.5	63.6	0 546	66	127	133	34	130
70	124.8	63.6	0.510	67	130	142	40	130
80	133.0	67.1	0.505	66	134	144	46	131
90	141.3	69.5	0.492	67	136	148	52	132
100	147.2	64.7	0.456	66	140	159	58	132
110	153.0	67.1	0.439	67	144	162	63	132
120	156.6	73.0	0.466	67	148	162	69	134
130	161.2	74.2	0.460	66	150	165	75	130
140	166.0	78.9	0.476	66	153	166	81	126
150	170.7	70.6	0.414	66	157	167	88	121

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When lifting water.

"Table II. shows the performance of the injector when lifting water 5 feet. The injector, as ordinarily constructed for use with high-pressure steam, has a spindle with a hole which is rather too small for low pressures; so that a spindle with a larger opening was attached in all but the last experiment, when the high-pressure spindle was replaced. The low-pressure spindle was such as is fitted in injectors designed for use on steamboats and other places where the pressure is ordinarily less than that carried in locomotive boilers.

Size of opening in spindle.

TABLE II.—*Maximum and Minimum Delivery of the Self-Adjusting* 1876 *Injector, No.* 6; *Temperature of delivered Water, and Pressure against which Injector delivers Water. Feed-Water lifted* 5 *Feet. Waste-Valve closed.*

Pressure of Steam supplied to Injector, and Pressure against which Water is delivered. *Lbs. per Sq. In.*	Delivery in Cubic Feet per Hour. Maximum.	Delivery in Cubic Feet per Hour. Minimum.	Delivery in Cubic Feet per Hour. Ratio of Minimum to Maximum Delivery.	Temperature, Fahrenheit Degrees. Feed-Water.	Temperature, Fahrenheit Degrees. Delivered Water. At Maximum Delivery.	Temperature, Fahrenheit Degrees. Delivered Water. At Minimum Delivery.	Pressure of Steam required to deliver Water against Pressure in Column 1.
1	2	3	4	5	6	7	8
30	84.8	53.0	0.625	68	123	124	16
60	114.2	67.1	0.559	68	130	134	34
90	137.7	65.9	0.479	68	139	152	51
120	150.7	77.7	0.516	68	149	156	70
150	150.7	88.3	0.586	68	170	160	97

Vacuum in supply-pipe.

"To obtain the vacuum in the supply-pipe, as recorded in Table III., a short supply-pipe was used, having a vacuum gauge connected to it, a globe-valve at the lower end of the pipe being immersed in a tank

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of water, so that the injector and supply-pipe could be heated by blowing steam through the supply-pipe, and could be cooled quickly to ordinary temperature by allowing the injector to draw water from the tank.

TABLE III.—*Vacuum in the Supply-Pipe of the Self-Adjusting* 1876 *Injector, No.* 6.

Pressure of Steam supplied to Injector. *Lbs. per Sq. In.*	Vacuum in Supply-Pipe—Inches of Mercury.			
	Injector fitted with Spindle having Large Hole.		Injector fitted with Spindle having Small Hole.	
	Injector at Ordinary Temperature.	Injector and Supply-Pipe as Hot as the Steam can make them.	Injector at Ordinary Temperature.	Injector and Supply-Pipe as Hot as the Steam can make them.
1	2	3	4	5
20	1	2½	......	......
30	4	1½	2	......
40	11	5	3	5
50	12	6½	3½	5
60	15	7½	5½	4¼
70	19¾	7½	6½	4¼
80	20½	8½	7½	5
90	20	7½	8½	5
100	20½	4	9½	5½
110	19½	3	10½	5½
120	19½	6	11	6
130	......	......	12½	6¼
140	......	......	13½	6½
150	......	......	19	7

"Experiments were then made to determine the steam-pressure required to lift water and start the injector, for such lifts as could conveniently be obtained in the testing-room, by throttling the steam until the lowest pressure at which the injector would start was ascertained. Using the high-pressure spindle, the pressure required for a lift of 3 ft. 4 in. was 33 lbs. per square

Steam-pressure required to lift water.

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inch; and for a lift of 5 ft., 47 lbs. per square inch. Lifting with this pressure, the injector delivered water against a pressure of 75 lbs. per square inch.

"Having started the injector with a pressure of 47 lbs. per square inch and a lift of 5 ft., the steam-pressure was gradually reduced, and the injector continued to deliver water until the steam-pressure was 10 lbs. per square inch, the water-pressure being 17 lbs. per square inch. Using the low-pressure spindle with larger hole, the steam-pressure required for a lift of 5 ft. was 30 lbs. per square inch. The injector and supply-pipe were then heated by blowing steam into the tank, and, with a steam-pressure of 150 lbs. per square inch and a lift of 4 ft., the injector was started in 3 seconds from the time of touching the starting-lever.

Low pressure spindle lifting water.

"Lifting water 5 ft., the highest temperature of supply-water with which the injector would start was as follows: With the high-pressure spindle and a steam-pressure of 120 lbs. per square inch, highest temperature of supply-water, 123°; 90 lbs., 130°; 60 lbs., 129°; and using the low-pressure spindle, at a steam-pressure of 30 lbs., 101°.

Starting temperature of supply-water when lifting.

"Experiments on the least pressure with which the injector would start, the water flowing to it under 15 inches head, resulted as follows:

Least pressure with which it would start.

"With a free discharge through safety-valve in delivery-pipe, equivalent to a water-pressure of 5 lbs. per square inch, the least steam-pressure with which the injector would start was 7 lbs. per square inch.

"Discharging into the boiler against a pressure equal to that of the steam, the least steam-pressure with which the injector would start was 8 lbs. per square inch.

Into boiler against same pressure as in injector.

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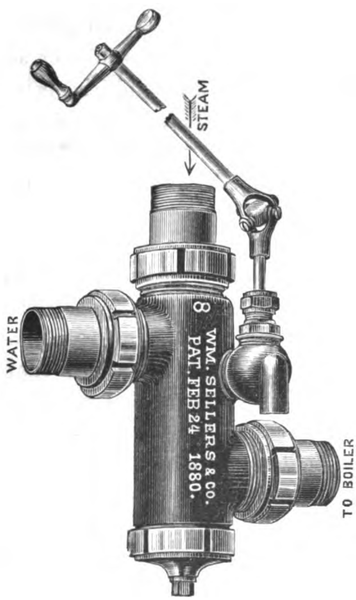
"When the injector was started, delivering water against a pressure of 5 lbs. per square inch, the steam-pressure was reduced by throttling to one-half pound per square inch before the injector ceased to work.

"Lifting 5 ft. with a steam-pressure of 120 lbs. per square inch, and a supply-pipe having one end free, the supply-pipe was violently shaken for the purpose of stopping the injector if possible. It was found that this could be done, but only by a peculiar shock of great violence,—much more violent, in fact, than would ever be likely to occur in practice.

Difficulty of causing the instrument to stop.

FIG. 144.



"Finally, the amount of water wasted in starting the injector was carefully measured, the average of a number of trials being 36 cubic inches, or about 1¼ U. S. pints.

Waste of water in starting.

"2. *The Non-Adjustable Injector with fixed Nozzles, non-lifting*, Figs. 144 and 145.—The No. 6 injec-

Non-lifting fixed nozzle.

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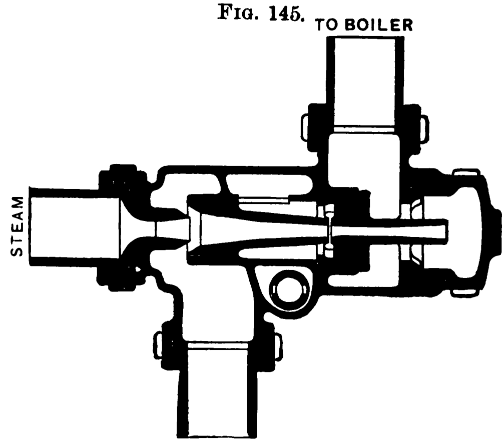
tor of this variety with which experiments were made looks externally like a cylindrical casting, open at one

FIG. 145.



end for connection with the steam, with two openings in the shell on opposite sides for connection with supply and delivery pipes, and a waste-valve which can be turned radially so as to discharge in any desired direction, and can be shifted so as to discharge on either side of the shell. There is a cap on the other end of the shell, and when this is removed the delivery and combining tubes can be drawn out for examination.

Size of injector.

The external diameter of this injector is 70 millimetres, or 2.8 in., and the total length 219.5 millimetres, or 8.6 in. It is apparently about as compact as such an instrument can well be made. Indeed, considering the appearance of injectors as ordinarily constructed, this instrument might readily be mistaken

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for a steam-fitting. In its action, however, as will be seen by reference to Table IV., it compares very favorably with larger and more complicated injectors. This injector, being non-adjustable, and having no valves attached to it, requires a check-valve in the delivery-pipe, a steam-stop valve, and a valve to regulate the amount of water supplied. The latter valve is necessary, because this injector, like all others having fixed nozzles, if not supplied with the proper amount of water for the steam-pressure under which it is working, will leak at the waste-valve when the water-supply is too great, and will draw in air if the water-supply is insufficient. This was fully proved by experiments in which, the injector being adjusted for maximum delivery under one pressure, the pressure was then varied, with the results just noted. It will be observed in Table IV. that the experiments on minimum delivery were made under two conditions in several instances,—with the waste-valve both open and closed. In ordinary practice, where the steam-pressure is not maintained sensibly constant, it is not considered desirable to work the injector with the waste-valve closed.

Valves needed.

Need of adjustment.

Method of starting.

"The manipulation of this injector, although not as simple as that of the '1876' instrument, presents no especial difficulty. It is necessary to open the water-supply valve sufficiently to deliver about the maximum amount of water that the injector can take at the given pressure, and, the waste-valve being open, as soon as the water escapes freely through the waste-orifice, to open the steam-valve slightly, until the jet is established, and then to open the steam-valve wide, by a quick motion. A special valve is provided for facilitating this manipulation.

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Table IV.—*Maximum and Minimum Delivery of the Fixed-Nozzle, Non-Lifting Injector, No.* 6; *Temperature of delivered Water, Pressure against which Injector delivers Water, and Highest Temperature admissible of Feed-Water. Water flowing to Injector under* 15 *Inches Head.*

Pressure of Steam supplied to Injector, and Pressure against which Water is Delivered. *Lbs. per Sq. In.*	Delivery in Cubic Feet per Hour. Maximum. Waste-Valve open.	Delivery in Cubic Feet per Hour. Minimum. Waste-Valve open.	Delivery in Cubic Feet per Hour. Minimum. Waste-Valve closed.	Delivery in Cubic Feet per Hour. Ratio of Minimum to Maximum Delivery. Waste-Valve open.	Delivery in Cubic Feet per Hour. Ratio of Minimum to Maximum Delivery. Waste-Valve closed during Minimum Delivery.	Temperature, Fahrenheit Degs. Feed-Water.	Temperature, Fahrenheit Degs. Delivered Water. At Maximum Delivery.	Temperature, Fahrenheit Degs. Delivered Water. At Minimum Delivery. Waste-Valve open.	Temperature, Fahrenheit Degs. Delivered Water. At Minimum Delivery. Waste-Valve closed.	Pressure of Steam required to deliver Water against Pressure in Column 1.	Highest Temperature admissible of Feed-Water, Fahrenheit Degrees. Waste-Valve open.	Highest Temperature admissible of Feed-Water, Fahrenheit Degrees. Waste-Valve closed.	Combining-Tube used.
1	2	3	4	5	6	7	8	9	10	11	12	13	14
10	63.6	21.3	......	0.335	....	69	106	167	......	3	......	110	Low Pressure.
40	101.2	30.6	......	0.302	....	69	116	206	......	23	......	144	"
70	124.8	48.3	34.1	0.387	0.273	69	130	208	250	40	132	152	"
100	101.2	68.3	.....	0.675	....	69	168	207	......	59	92	133	"
100	143.6	63.6	51.8	0.443	0.361	69	134	205	235	60	112	151	High Pressure.
120	157.7	75.3	61.2	0.478	0.388	69	142	210	237	73	108	152	"
150	129.1	98.9	68.3	0.766	0.529	69	166	199	241	99	99	144	"

Comparison in favor of 1876 injector.

"Another important difference between the injector with fixed nozzles and the self-adjusting injector is illustrated by comparing the maximum delivery of the two injectors, at different steam-pressures, as recorded in column 2 of Tables I. and IV. respectively. It will be seen that the maximum delivery of the self-

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adjusting injector increases continually with increase of steam-pressure, while the fixed-nozzle injector has a maximum delivery at a steam-pressure depending upon the proportions of the combining-tube, which is greater than the maximum delivery for any other steam-pressure, either higher or lower. Thus, it appears from Table IV. that using a combining-tube adapted for a pressure of 70 lbs. per sq. in., the greatest amount of water is delivered by the injector at this pressure; and that on replacing this combining-tube by one adapted to a steam-pressure of 120 lbs. per sq. in., similar results are obtained,—the amount of water delivered by the injector, in each instance, decreasing as the steam-pressure is increased beyond the point for which the combining-tube is proportioned. This is true of all injectors with fixed nozzles, so that the self-adjusting injector possesses advantages apart from the ease with which it adapts itself to varying steam-pressure and water-supply. Still, there are many localities where injectors can be worked under practically constant conditions, and for such situations the non-adjustable injector is well adapted; while the simplicity of this particular form, and the ease with which its internal parts can be examined and removed, will doubtless prove strong recommendations.

When this kind of instrument is useful.

"Although this injector has no lifting attachment, it can be made to lift water when once started under a head in the supply-pipe. This was illustrated by starting the injector with a steam-pressure of 22 lbs. per sq. in., the water flowing to it under 15 inches head, and then suddenly changing the connections so that the supply was obtained from the lower tank with a lift of 3 ft., the injector continuing to deliver

Can be made to lift.

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water under these conditions. This action is probably the same as that of a siphon, which will continue to work when once charged, but cannot start unless the pipe is first filled. There being a vacuum at some point of the delivery-tube when the jet is established and the injector is at work, this acts in a similar manner to the long leg of an ordinary siphon, and the flow continues.

Fixed nozzle with lifting attachment.

"3. *The Non-Adjustable Injector, with fixed Nozzles, in connection with a Lifting Attachment*, Figs. 146 and 147.—Attached to one side of this injector is an ejector or steam-siphon which draws water, when lifted by the admission of steam, through the combining-tube, and discharges it through the orifice of the lifting attachment, through which also the waste-overflow takes place. This injector has a check-valve connected to it, also a steam-stop valve, which can be opened wide by half a revolution of the lever on the stem. In connecting the injector, since it has fixed nozzles, a water-supply valve must be provided, and, as already remarked, a second check-valve in the delivery-pipe and another steam-stop valve are desirable.

Starting.

"In starting this injector, steam is first admitted to the lifting-nozzle, the water-supply valve being adjusted so as to deliver about the maximum amount of water corresponding to the steam-pressure; and as soon as solid water issues from the lifting-nozzle, the steam-valve is to be opened slightly until the jet is established, when the full steam-pressure is to be admitted, and the valve that admits steam to the lifting-nozzle is to be closed.

Dexterity needed to start at maximum lift.

"Some little dexterity is required to start the injector for a maximum lift, but the manipulation is readily acquired. As the velocity of steam escaping

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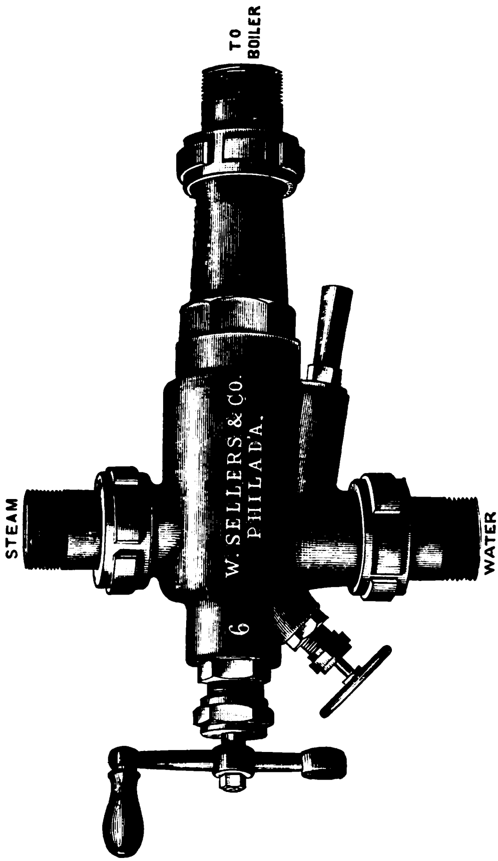
from an orifice varies greatly with the pressure, other things being equal, the lifting-nozzle must have pro-

FIG. 146.



portions depending on the minimum steam-pressure to be employed, since it can readily be adapted to higher pressures by partially closing the steam-admission valve. The lifting-nozzle on the injector with

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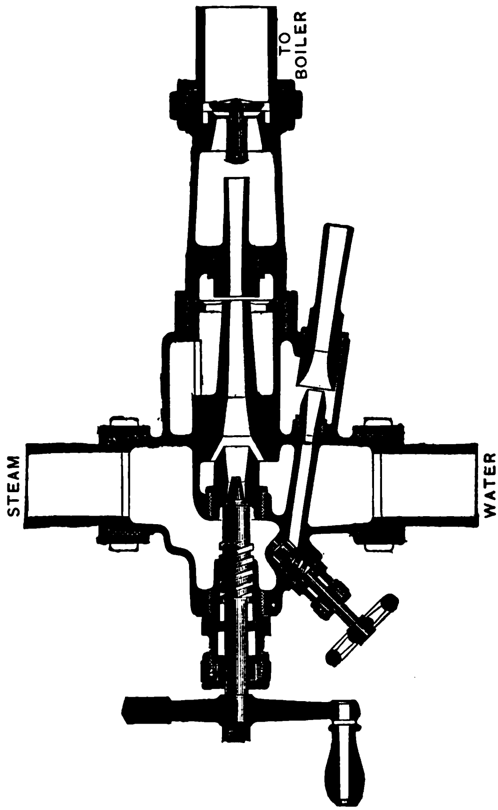
which the following experiments were made was proportioned for a minimum steam-pressure of 60 lbs. per sq. in.; and it was found that the results obtained

Fig. 147.



at that pressure were not materially exceeded at higher steam-pressures, while there was a rapid decrease in the vacuum and lift for steam-pressures below 60 lbs. per sq. in.

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"Table V. shows the vacuum indicated on a gauge connected to the supply-pipe at different steam-pressures, the experiments being conducted similarly to those made with the '1876' injector.

Vacuum obtained.

TABLE V.—*Vacuum in Supply-Pipe of the Fixed-Nozzle Lifting Injector, No.* 6.

Pressure of Steam supplied to Injector. *Lbs. per Square Inch.*	Vacuum in Supply-Pipe—Inches of Mercury.	
	Injector at Ordinary Temperature.	Injector and Supply-Pipe as Hot as the Steam can make them.
30	7	$7\frac{1}{4}$
60	$24\frac{3}{4}$	$24\frac{1}{4}$
90	$24\frac{1}{2}$	$24\frac{1}{2}$
120	24	24
150	24	23

"It is considered by some that the indications of a vacuum-gauge connected to the supply-pipe of an injector represent the actual lift that can be obtained. The experiments made with this injector, however, do not confirm this opinion. For the purpose of ascertaining the maximum lift, the injector was connected at the top of the scaffolding to which reference has been made, and the heights to which water could be lifted and delivered were carefully measured, the lifts being varied by changing the length of the supply-pipe, the boiler-pressure being also varied for each lift, until a steam-pressure was reached at which the injector would raise and deliver the water. The results of these experiments are contained in Table VI. It will be seen that no advantage was derived from increasing the steam-pressure beyond 60 lbs. per sq. in., while the decrease in lift was rapidly accelerated as

Vacuum does not correspond to actual lift.

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the steam-pressure was reduced. It is believed there were no leaks in the supply-pipe used in these experiments, but the greatest lift obtained is by no means an equivalent for the best vacuum recorded in Table V. This suggests that records of lifts based on the indications of a vacuum-gauge may not be very reliable.

TABLE VI.—*Steam-Pressure required to lift and deliver Water with the Fixed-Nozzle Lifting Injector*, No. 6.

Height Water is lifted.		Steam-Pressure required to lift and deliver Water.	Height Water is lifted.		Steam-Pressure required to lift and deliver Water.
Feet.	*Inches.*	*Lbs. per Square Inch.*	*Feet.*	*Inches.*	*Lbs. per Square Inch.*
3	0	25	21	3	52
5	0	30			60
11	6	40	22	10	70
15	0	49			100

Low pressure nozzle.

"On the completion of the experiments just described, the lifting-nozzle was replaced by one adapted to a lower steam-pressure, and the injector was started with a steam-pressure of 49 lbs. per sq. in., and a lift of 21 ft. 10 in.; after which the steam was throttled, the water-pressure being similarly reduced, the injector continuing to work until the steam-pressure was reduced to 7 lbs. per sq. in., the water-pressure being 10 lbs. From this it will be seen that by the aid of a priming attachment the injector could be started at a much lower steam-pressure than that for which the lifting-nozzle is adapted.

Priming attachment.

Duty of the Sellers injectors.

"*Duty of Sellers Injectors.*—A final note in relation to the duty of injectors, or the foot-pounds of useful work performed by the consumption of 100 lbs. of coal in the boiler supplying steam to the injector, may be of interest. When the evaporation of the boiler

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Duty of the Sellers injectors.

is known, this duty can readily be computed from the data obtained in connection with the maximum delivery of the injector. This can be illustrated by an example, assuming the boiler evaporation at 9 lbs. of steam per lb. of coal, a result which, though rather above the average, is occasionally exceeded in good practice. Using the data recorded in Table I. for the maximum delivery at a steam-pressure of 130 lbs. per sq. in., it appears that $150 - 66 = 84$ units of heat were imparted to each pound of water delivered by the injector, and, the weight of a cubic foot of water at a temperature of 66° F. being about 62.3 lbs., that the total weight of water delivered per hour was $161.2 \times 62.3 = 10{,}042.76$ lbs.; so that the total amount of heat imparted to the water per hour was $10{,}042.76 \times 84 = 843{,}591.84$ units.

"The total heat above 32° in a pound of dry steam, at a pressure of 130 lbs. per sq. in., is 1187.8 units, and the heat remaining in a pound of steam above 32°, after condensation, was $150 - 32 = 118$ units; so that each pound of dry steam imparted $1187.8 - 118 = 1069.8$ units of heat to the feed-water, and the weight of dry steam required per hour was $\frac{843{,}591\ 84}{1069.8} = 788.6$ lbs. The height of a column of water equivalent to the pressure against which the water was delivered was $\frac{144 \times 130}{62.3} = 300.5$ ft., so that the useful work performed per hour was $10{,}042.76 \times 300.5 = 3{,}017{,}049.38$ foot-pounds. The weight of coal required to do this work, on the assumed boiler evaporation, was $\frac{788.6}{9} = 87.6$, so that the duty of the injector, per 100 lbs. of coal, was $\frac{3{,}017{,}049.38 \times 100}{87.6} = 3{,}455{,}536$ foot-pounds."

It will be observed that the writer of the above re-

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Duty of the Sellers Injectors.

port has concluded his account of the experiments with a calculation of the duty of the "Sellers Injector." This calculation being given in full, will enable users of these instruments to test the duty of any injector on the same basis, if they can obtain for themselves the data which enter into the example given.

Position on the engine.

The new form of instrument, known as our Injector of 1876, was especially designed for use on locomotives, and it is believed that all the requirements of a perfect boiler-feeder have been secured. The instrument can be placed in any convenient position in the "cab," regardless of its height above the level of the water in the tank, as it works best when lifting its supply of water.

Facility of starting.

A simple motion of the working lever *H* of the instrument starts, stops, or regulates the quantity of delivery with an ease and certainty never before attained.

Dispenses with the usual expensive valves.

All the starting-valves and extra attachments forming the necessary adjuncts of other injectors are dispensed with. Its use is reduced to the minimum of simplicity in manipulation, and its efficiency very much increased. With it, no possible excuse can be raised by the engine runner. It is not so troublesome to operate as a pump.

Will start with hot pipes.

One remarkable feature of the new instrument is the readiness with which it will "take water" when it and its connecting water-pipes have become heated by blowing back steam through them into the water-tank. Little difference can be noted in the starting whether the pipes be hot or cold.

We have said that the self-adjusting injector works well when lifting water or when the water flows to it without any pressure. Water fed under pressure, say from the street mains, will, if admitted directly to the instrument, disturb its action. To meet this difficulty

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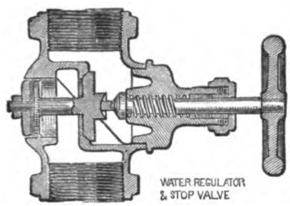
we make a water-regulating and stop-valve. This (see Fig. 148) is so constructed as to serve the double purpose of stop-valve and water regulator; it should be placed in the feed-pipe, below the injector. **Water-regulating valve.**

Fig. 148.



In using this in connection with the Injector of 1876, which *contains an air-chamber*, a drain-cock must be arranged between the water-regulating and stop-valve and the injector, for the purpose of replenishing the chamber with air.

The original instrument of Giffard was not self-regulating; it required adjustment both for steam and water. It possessed, however, the advantage of working well under pressure. We now substitute for this form of instrument our new fixed-nozzle injectors, arranged either to lift water or to operate under a head. They recommend themselves for their efficiency, simplicity, and ease of access to their parts. On pages 378 and 379 the case has been fairly stated in the report of the Park Benjamin Expert Office, where it is shown that at certain fixed pressures of steam these instruments give admirable results; and as the pressure carried on stationary boilers is in the main very constant, these injectors can be advantageously used. They are furnished for either 70 lbs. pressure or 120 lbs. pressure per square inch; each instrument working quite well at a considerable range

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above or below their pressures, but best at the pressures for which they have been set. The 70 lbs. pressure instrument answering for most stationary purposes, the 120 lbs. pressure are for locomotives, or wherever the steam pressure is carried high, as is the case on some portable engines. These instruments can be erected with ordinary steam fittings, globe valves and stop-cocks.

Of the two new styles of fixed-nozzle injectors, the non-lifting one has no valves attached to it; it therefore requires a check-valve in the delivery-pipe between the instrument and the boiler, a steam stop-valve, and a regulating cock or valve in water-supply pipe. The latter valve is necessary, because this injector, like all others having fixed nozzles, if not supplied with the proper amount of water for the steam-pressure under which it is working, will leak at the waste-valve when the water supply is too great, and will draw in air if the water supply is not great enough. In ordinary practice, when the steam pressure is not maintained sensibly constant, it is not considered desirable to work the injector with the waste-valve closed.

Numerical size of injector.

The numerical size of any injector is the diameter of the smallest part of the delivery-tube, expressed in millimetres. Thus, a No. 2 injector of any one of the Giffard injectors, or any of the many styles of improved instruments made by us, has an opening of 2 millimetres diameter, through which the water is forced in passing through the delivery-tube, while in a No. 10 this part of the instrument measures 10 millimetres in diameter.

Range of capacity.

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Table of Maximum Capacities of Patent Self-Adjusting Injectors.

SIZE.	Size of Pipe for Connections.	PRESSURE OF STEAM, IN POUNDS.						
		10	20	30	40	50	60	70
		CUBIC FEET OF WATER DISCHARGED PER HOUR.						
No. 2	½ in.	8.3	9.	9.7	10.4	11.1	11.8	12.5
" 3	¾ "	19.27	21.04	22.81	24.58	26.35	28.12	29.89
" 4	1 "	36.66	39.6	42.74	45.88	49.02	52.16	55.3
" 5	1¼ "	57.58	62.5	67.42	72.34	77.26	82.18	87.1
" 6	1¼ "	83.48	90.6	97.72	104.84	111.97	119.09	126.21
" 7	1½ "	114.03	123.75	133.48	143.2	152.93	162.65	172.38
" 8	2 "	149.2	162.	174.8	187.6	200.4	213.2	226.
" 9	2 "	189.2	205.35	221.51	237.66	253.82	269.97	286.13
" 10	2 "	233.84	253.8	273.76	293.72	313.68	333.64	353.61
" 12	2½ "	337.2	366.	394.8	423.6	452.4	481.2	510.
" 14	2½ "	451.49	491.45	531.41	571.36	611.32	651.27	691.23
" 16	3 "	600.32	651.6	702.88	784.16	805.44	856.72	908.
" 18	3 "	760.07	825.	889.93	954.86	1019.78	1084.71	1149.64
" 20	3½ "	938.84	1019.	1099.16	1179.32	1259.48	1339.64	1419.8

SIZE.	PRESSURE OF STEAM, IN POUNDS.							
	80	90	100	110	120	130	140	150
	CUBIC FEET OF WATER DISCHARGED PER HOUR.							
No. 2	13.2	13.9	14.6	15.3	16.	16.7	17.4	18.1
" 3	31.66	33.43	35.2	36.97	38.75	40.53	42.31	44.09
" 4	58.44	61.58	64.72	67.86	71.	74.14	77.28	80.42
" 5	92.02	96.94	101.86	106.78	111.7	116.62	121.54	126.46
" 6	133.33	140.45	147.57	154.7	161.82	168.94	176.06	183.18
" 7	182.1	191.83	201.55	211.28	221.	230.73	240.46	250.19
" 8	238.8	251.6	264.4	277.2	290.	302.8	315.6	328.4
" 9	302.28	318.44	334.59	350.75	366.9	383.07	399.23	415.39
" 10	373.57	393.53	413.49	433.45	453.41	473.37	493.33	513.29
" 12	538.8	567.6	596.4	625.2	654.	682.8	711.6	740.4
" 14	731.18	771.14	811.09	851.05	891.	930.97	970.93	1010.89
" 16	959.28	1010.56	1061.84	1113.12	1164.4	1215.68	1266.96	1318.24
" 18	1214.57	1279.5	1344.42	1409.35	1474.28	1539.21	1604.14	1669.07
" 20	1499.96	1580.12	1660.28	1740.44	1820.6	1900.76	1980.92	2061.08

The minimum capacity 50 per centum of the maximum for old style self-adjusting and 40 per centum for the "Injector of 1876."

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Temperature of supply-water.

The quantity of water that can be made to pass through this opening depends upon two conditions: the pressure of the steam and the temperature of the supply-water before it enters the instrument,—*i.e.*, before it comes in contact with the steam in the combining-tube of the injector. The colder the water, the more will be thrown with a good amount of steam.

In regard to the temperature of feed-water, a notable difference exists between the old form of our self-adjusting injector and the injector of 1876.

For the old style we have:

Scale of temperature and pressure.

Pressure of steam in pounds per square inch..............	10	20	30	40	50	100	120
Admissible temperature of feed-water before it enters injector....................	148°	138°	130°	124°	120°	110°	90°

For the injector of 1876 actual experiment gives:

Pressure of steam in pounds per square inch	20	40	60	80	100	120	140	150
Admissible temperature of feed-water before entering injector....................	138°	135°	130°	130°	132°	133°	127°	128°

Increased range.

With this increased capacity to take hot water there also comes with the new instrument an increased range. The new injector of 1876 comes the nearest of any instrument yet made to working through a great range with varying conditions of temperature of the feed. Approximately the matter may be expressed thus:

The old-style adjustable injector has a minimum delivery of 60 per cent. of its maximum capacity, under favorable conditions of temperature and pressure.

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The old-style self-adjusting injector (see pp. 408 and 409) has its minimum at 50 per cent. of its maximum. **Percentage of range.**

The injector of 1876 has a minimum of 40 per cent. of its maximum.

Assuming the maximum the same with these injectors, we have:

Adjustable, 100 cubic feet maximum, 60 cubic feet minimum.

Old-style, self-adjusting injector, 100 cubic feet maximum, 50 cubic feet minimum.

Injector of 1876, 100 cubic feet maximum, 40 cubic feet minimum.

The range is increased, and its capacity to take hot water is increased also; and, added to these advantages, the self-adjusting injectors have a higher maximum than the adjustable instrument.

Required size of injector. TO DETERMINE THE SIZE of instrument needed for any particular case, a knowledge of the number of cubic feet of water required per hour will enable an instrument to be selected, by referring to the table of capacities for any special kind of instrument, taking into consideration the ratio of range of each style.

Horse-power given. GIVEN THE INDICATED HORSE-POWERS, the quantity of water required may be approximately assumed by considering each horse-power to require one cubic foot of water per hour. If steam is used expansively to any great extent, as in some of the best modern engines, the quantity of water per horse-power may be reduced, say 33 per cent. In no case, however, should the injector selected be larger than will give at maximum the number of cubic feet of water corresponding with the number of horse-power, inasmuch as the range of each style of instrument is limited, as has been shown above, to 60 per cent. **Should not be too large.**

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of the maximum capacity as the minimum in the adjustable, 50 per cent. in the self-adjusting, and 40 per cent. in the injector of 1876. If too large an instrument is selected, the minimum may sometimes be too great for the wants of the boiler, requiring frequent stoppages to prevent flooding, which, apart from the trouble involved, is not so economical as a constant and regular feed, equal to the drain on the boiler. For stationary purposes the selecting the size of instrument for any particular case is a simple matter when the work required for the boiler is in any degree constant. For locomotive use the problem is a more complicated one, requiring more precision, and in some cases greater range, than can possibly be obtained from one instrument. This makes the use of two injectors advisable on some engines doing certain duty.

For stationary purposes.

Two instruments sometimes needed.

Rules to determine horse-power of boiler.

To approximate the horse-power of any boiler the following rules are useful:

When area of grate surface is known.

Rule: Area of grate in square feet $\times 1.6 =$ horse-power.

For plain cylinder boilers.

Rule: Heating surface of boiler in square feet divided by 10 = horse-power.

For flue boilers.

Rule: Heating surface of boiler in square feet divided by 12 = horse-power.

For multitubular boilers.

Rule: Heating surface of boiler in square feet divided by 15 = horse-power.

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RULES TO BE OBSERVED IN SETTING INJECTORS.

IT is of the utmost importance that care be taken in setting all kinds of injectors by those who attach them to the boilers; such care will often avoid trouble afterwards. The requirements are simple, and may be enumerated thus:

Size of pipes.

FIRST. All pipes, whether steam, water-supply, or delivery, must be of the same internal diameter as the hole in the corresponding branch of each injector, and as short and straight as practicable.

Screen over water-supply pipe.

SECOND. When floating particles of wood or other matter are liable to be in the supply-water, a strainer must be placed over the receiving end of the water-supply pipe. The holes in this strainer must be as small as the smallest opening in the delivery-tube, and the total area of all the holes must be much greater than the area of the water-supply pipe, to compensate for the closing of some of them by deposits. The smallest part of the delivery-tube measures the name of instrument in millimetres. Thus the No. 2 injector is 2 mm. diameter; the No. 8 is 8 mm. diameter, or say $\frac{5}{16}$ inch diameter. So with all other sizes. A millimetre is .039 of an inch.

Size of holes in strainer.

Dry steam only to be used.

THIRD. The steam should be taken from the highest part of the boiler, to avoid the carrying over of water with the steam. "Dry-pipes" should always be used on locomotives to insure dry steam; wet steam cuts and grooves the steam-spindle and the steam-nozzle. The steam should not be taken from the steam-pipe leading to an engine, unless such pipe is large. Sudden

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variations in pressure may break the jet in the old styles of injectors, and will produce a constant movement of the piston in the self-adjusting instrument.

Must not draw air.

FOURTH. When any injector capable of raising water is set so as to lift the water, care must be taken to have the pipes very tight, so as not to draw air; and it is of importance that in any arrangement of instrument the water-supply should be unmixed with air, which will cause a sputtering sound, and is liable to break the jet.

Cock in supply-pipe.

FIFTH. If the water is not lifted by the injector, but flows to it from a tank or hydrant, there should be a cock in the water-supply pipe; and in case of the use of the self-adjusting injector, this cock should be of a kind that will prevent any considerable pressure in the water-supply pipe between this cock and the injector. In other words, the WATER MUST NOT ENTER THE INSTRUMENT UNDER ANY CONSIDERABLE PRESSURE. The reason of this is, in all self-adjusting injectors the range is diminished by pressure in the supply-pipe. The amount of this disturbance may be expressed as follows:

Effect of pressure on range.

A No. 8 injector will give a fair range—say its minimum may be taken at 60 per cent. of its maximum—when fed under a pressure of 40 feet head of water, or about 20 pounds water-pressure to the square inch. The higher the steam is carried in the boiler the greater may be the pressure in the water-supply pipe. A No. 2 injector will not bear nearly so high a pressure; under 40 feet head of water it will require steam of 80 pounds pressure.

To obtain the *best* results in range the self-adjusting injector should be set to lift water, or should be fed through a self-regulating valve when the head exceeds a few feet.

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SIXTH. There must always be a stop-valve or cock in the steam-pipe between the steam-space in the boiler and the injector, and a check-valve between the water-space of boiler and the injector. Cocks needed.

SEVENTH. The air-chamber in the body of the injector of 1876 must be well supplied with air. In this respect no precaution is needed when the injector lifts water from a tank placed below it, inasmuch as the water flows back and air enters through the injector when it is stopped. Air-chamber.

When fed from a hydrant through a self-regulating valve, there should be a pet-cock between the valve and the air-chamber, which will serve to drain away the water when the valve is closed and the injector is not working. Cock to let out water.

N.B.—After all the pipes are properly connected to the injector and to the boiler, and before steam and water are admitted through them to the injector, they should be disconnected and well washed out by blowing steam or running water through them, to wash out all red lead, scale, or other solids that may be in the pipes. We have had new injectors returned to us as out of order, which, upon examination, have been found full of red lead, or hemp and red lead, or other impurities from the interior of the pipes. See that all pipes are clean. Pipes must be all clean.

We have also had injectors returned to us from a distance plugged up with bits of wood carried in with the supply of water. This trouble would have been avoided by the use of a strainer.

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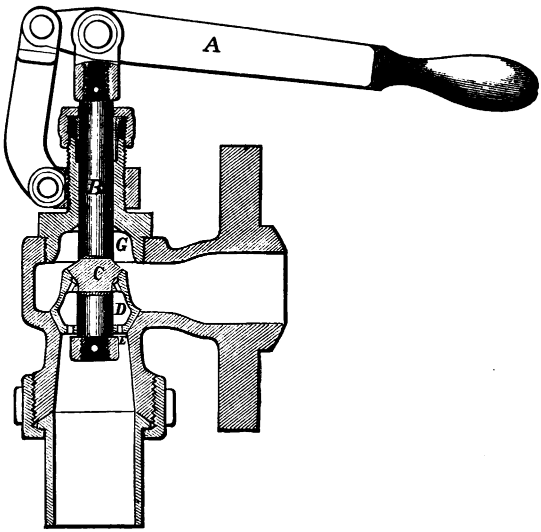
When injectors are used with water containing much lime, liable to cause deposits in the boiler, there will be a deposit take place in the injector. When this occurs, the instrument must be taken apart, and

FIG. 149.



the tubes or nozzles cleaned carefully. The new fixed nozzle injectors are especially adapted to facilitate this, as they are so easily opened and cleaned. When new parts are required to replace old ones, we should be informed of size and style of instrument. With such description should always be sent the progressive trade number to be found on the body of the instrument.

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SPECIAL ATTACHMENTS.

To facilitate the efficient use of the instrument, we have arranged special attachments, such as starting valves, either screw or lever, check-valves, etc. **Extra attachments.**

STARTING VALVES. Before the introduction of our injector of 1876, it was necessary to use with our self-adjusting injector, when it was set to lift water, a starting valve of peculiar construction. This valve is not required with the new instrument; with it any ordinary globe valve may be used between the injector and the boiler. Wherever our old style of self-adjusting injector (see pp. 408 and 409) is used to lift water, this starting valve is still necessary. It is also admirably adapted for use with our fixed nozzle non-lifting injector. **Starting valve.**

Our starting valve (shown in Fig. 149) is operated by a lever A; its stem B is attached to the valve D, with a lost motion between C and E. C is, in fact, a small valve in the centre of a larger valve D. Pressure of the boiler is on top of the valves in space G. Raising the lever and drawing up the valves, the small valve C will leave its seat on D, and rise until a check nut at E has brought up against D. This resistance can be distinctly felt, and indicates when the small valve only is open. Through this small valve enough steam will pass to start the jet. A further motion of the lever then raises the large valve, and the pressure, acting on the stem B, forces it wide open and holds it in this position. **Description of starting valve**

These valves, with or without flanges to suit convenience of attachments to boiler, are furnished as indicated in the cuts, Figs. 150 and 151.

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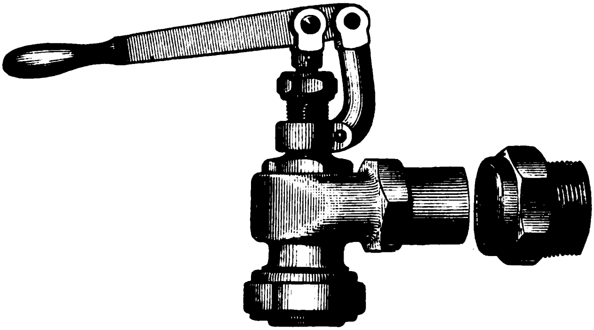
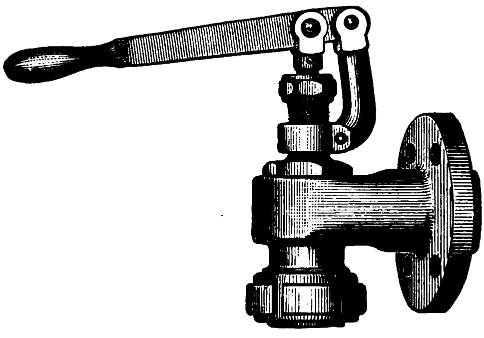
FIG. 150.



(A.) STARTING VALVE, WITHOUT FLANGE.

FIG. 151.



(B.) STARTING VALVE, WITH FLANGE.

Main check-valves.

We also make a starting valve for straight way pipe for stationary purposes.

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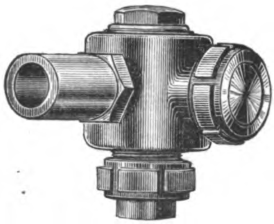
MAIN CHECK-VALVES.

The main check-valves for locomotives are usually constructed to take their water below the valve, the pipe union pointing downwards, but as the injector is preferably placed above the check, the use of such a valve involves a needless bend in the pipe leading to the main check. To meet all requirements of the trade we make such check-valves as shown in Fig. 152, which represents a check for the right-hand side of the engine.

FIG. 152.



This valve has ingress below the valve or at the side, the opening not coupled to the feed-pipe being closed by a blank cap under a coupling-nut, which nut and cap may be readily removed for the purpose of cleaning the case below the valve. Our cut represents this form of main check-valve as arranged for the right-hand side of the engine; we have them also for the left-hand side, and we make the cases with flange connection to bolt to boiler when so ordered.

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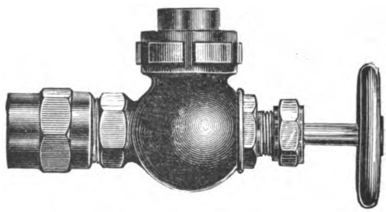
ANGLE VALVE.

Adapted to the use of our Injector of 1876.

As already stated on page 397, a special starting valve is not required with the injector of 1876; any well-made globe-valve answers between the injector and the boiler. For convenience especially on locomotives we have designed the angle valve shown in Fig. 153, which answers the case perfectly, and is readily attached to the boiler. This valve has gone extensively into use with our injectors of 1876.

FIG. 153.



ANGLE GLOBE-VALVE.

In conclusion, we may add that the injectors now presented are the result of many years of careful experimentation. During the existence of the Giffard patent we were the sole makers of this instrument in the United States, but during these years we were unsparing in our endeavors to perfect the instrument, and the introduction of our self-adjusting principle finally perfected in the instrument of 1876, was one of the results growing out of this continual search for the best effects. We have made very many different forms of injectors; what we now present are what we believe best fitted to meet all the wants of steam users in the way of boiler-feeders.

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INTERNATIONAL EXHIBITION,

PHILADELPHIA, 1876.

The United States Centennial Commission has examined the report of the Judges, and accepted the following reasons, and decreed an award in conformity therewith.

PHILADELPHIA, NOV. 29, 1876.

REPORT ON AWARDS.

PRODUCT: Injector.

Name and Address of Exhibitors: William Sellers & Co., Philadelphia, Pa.

The undersigned having examined the product herein described, respectfully recommends the same to the United States Centennial Commission for award, for the following reasons, viz.:

That they exhibit an Injector that is self-regulating, is simple in plan, readily operated, and is in material and workmanship of the highest order.

[Signature of the Judge.] HORATIO ALLEN.

APPROVAL OF GROUP JUDGES.

CHAS. T. PORTER, EMIL BRUGSCH, W. H. BARLOW,
W. PETROFF, F. REULEAUX, CHAS. E. EMERY.
JOSEPH BELKNAP,

A true copy of the record.

FRANCIS A. WALKER,
Chief of the Bureau of Awards.

Given by authority of the United States Centennial Commission.

A. T. GOSHORN, *Director-General.* J. L. CAMPBELL, *Secretary.* J. R. HAWLEY, *President.*

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WM. SELLERS & CO.,

PATENTEES AND SOLE MANUFACTURERS

OF THE

1876 SELF-ADJUSTING INJECTOR.

NO SPECIAL VALVES OR FITTINGS REQUIRED.

WE have had this improved form of our injector in constant use since July, 1876, and find it works well under all conditions of service met with. It is *started*, *regulated* as to capacity, or stopped *by one lever*. It *lifts* water *readily*, and will start *easily*, even after the injector and water-supply pipe have been heated by blowing steam through them.

This injector is intended for use on the RIGHT hand side of an engine, instead of the pump. It should be attached so that the *bottom of the injector is as high as the top of the tank*, and the lever *inside* the *cab*, within convenient reach of the engineer. It is not necessary to watch the overflow to know when it catches the water, or when the injector is working, as its operation can be *felt* through the starting lever.

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PRICE LIST.

SIZE No.	PRICE.			SIZE OF PIPES.			
				STEAM AND DELIVERY.		WATER SUPPLY.	
	Injector.	Steam Valve.	Check.	Iron.	Copper.	Iron.	Copper.
3	\$30.00	\$6.00	\$5.00	$\frac{3}{4}$ in.	1 in.	$\frac{3}{4}$ in.	1 in.
4	42.00	7.00	6.50	1 "	$1\frac{1}{8}$ "	1 "	$1\frac{1}{8}$ "
5	55.00	8.75	8.00	$1\frac{1}{4}$ "	$1\frac{1}{2}$ "	$1\frac{1}{2}$ "	$1\frac{3}{4}$ "
6	70.00	8.75	8.00	$1\frac{1}{4}$ "	$1\frac{1}{2}$ "	$1\frac{1}{2}$ "	$1\frac{3}{4}$ "
7	85.00	8.75	8.00	$1\frac{1}{4}$ "	$1\frac{1}{2}$ "	$1\frac{1}{2}$ "	$1\frac{3}{4}$ "
8	100.00	13.50	12.50	2 "	2 "	2 "	$2\frac{1}{4}$ "
9	115.00	13.50	12.50	2 "	2 "	2 "	$2\frac{1}{4}$ "
10	130.00	13.50	12.50	2 "	2 "	2 "	$2\frac{1}{4}$ "

DRY PIPE CONNECTION FOR STEAM VALVES. Price, \$1.50.

THE STEAM SPINDLE IS FITTED WITH A DOUBLE VALVE.

TO WORK THE INJECTOR, lift the first valve until you feel the resistance of the main valve; *this lifts the water.* When water runs from the overflow, steadily draw back the lever all the way.

TO REGULATE THE FEED, push in the lever to the requisite notch.

TO USE AS A HEATER, lift both valves at once.

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WM. SELLERS & CO.

PATENTEES AND SOLE MANUFACTURERS

OF THE

FIXED NOZZLE LIFTING INJECTOR.

PRICE LIST.

SIZE No.	PRICE.				SIZE OF PIPE. Iron.
	Injector.	Steam Valve.	Regulating Valve.	Check Valve.	
2	$22.00	$1.80	$1.80	$1.08	½ in.
2½	26.00	1.80	1.80	1.08	½ "
3	30.00	2.40	2.40	1.32	¾ "
4	42.00	3.30	3.30	1.80	1 "
5	55.00	4.20	4.20	2.40	1¼ "
6	70.00	4.20	4.20	2.40	1¼ "
7	85.00	5.52	5.52	3.12	1½ "
8	100.00	7.80	7.80	4.80	2 "
9	113.00	7.80	7.80	4.80	2 "

THE ABOVE ARE ALL BRASS.

TERMS: Cash, upon delivery at our Works.

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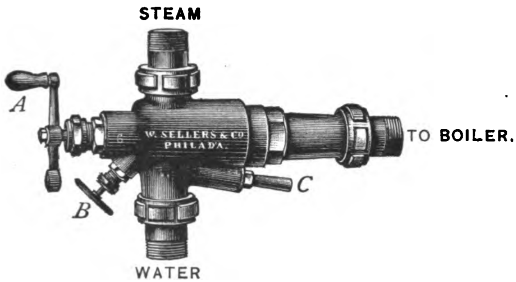
DIRECTIONS FOR OPERATING.



1st. Screw in steam-spindle *A*.

2d. Open lifting-jet by a quarter turn of the wheel *B*.

3d. When water runs out of overflow *C*, screw out steam-spindle *A* quickly.

4th. Close lifting-jet *B*. (If the water flows to the injector it is not necessary to use the lifting-jet, and it (wheel *B*) should be kept closed.)

The injector will now be feeding the boiler, and the supply of water can be regulated by an ordinary globe-valve between the injector and the water-supply; a proper regulation will give sixty-six per cent. range. If this valve is set to admit the proper quantity of water, dry steam will issue from overflow when spindle is run out, and will cease when lifting-jet is closed.

For convenient regulation we offer a special regulating valve (see Price List) which has but one turn to the screw, and a boss upon the hand-wheel to indicate the position of the valve; the valve itself being somewhat modified for convenient regulation, so that the operator can determine the amount of feed by the position of the hand-wheel.

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WM. SELLERS & CO.

PATENTEES AND SOLE MANUFACTURERS

OF THE

FIXED NOZZLE NON-LIFTING INJECTOR.

PRICE LIST.

SIZE No.	PRICE.				SIZE OF PIPE. Iron.
	Injector.	Steam Valve.	Regulating Valve.	Check Valve.	
2	$22.00	$1.80	$1.80	$1.08	½ in.
2½	26.00	1.80	1.80	1.08	½ "
3	30.00	2.40	2.40	1.32	¾ "
4	42.00	3.30	3.30	1.80	1 "
5	55.00	4.20	4.20	2.40	1¼ "
6	70.00	4.20	4.20	2.40	1¼ "
7	85.00	5.52	5.52	3.12	1½ "
8	100.00	7.80	7.80	4.80	2 "
9	118.00	7.80	7.80	4.80	2 "

THE ABOVE ARE ALL BRASS.

TERMS: Cash, upon delivery at our Works.

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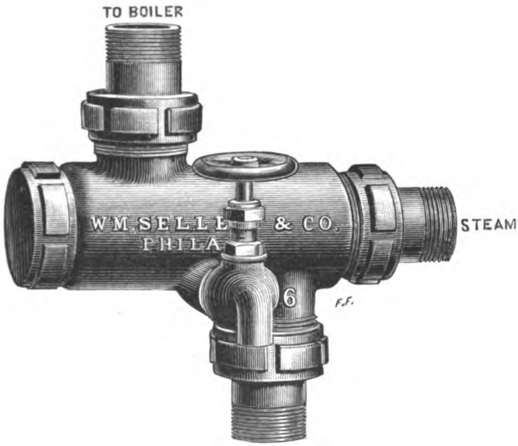
DIRECTIONS FOR OPERATING.



1st. Turn on the water.

2d. Open steam-valve slightly, then open wide quickly.

3d. Regulate supply of water to the injector by the water-valve.

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WM. SELLERS & CO.,

PATENTEES AND SOLE MANUFACTURERS

OF THE

PATENT SELF-ADJUSTING INJECTOR OF 1873.

PRICE LIST.

SIZE. No.	Self-Adjusting Injector.		Size of Pipe for Connections of Iron.	Starting Valve.	Regulating Valve.	Alarm Check-Valve.	Drip-pan for Waste-Pipe.	Attachments Complete with Connections to Injector.
	Brass Body Polish.	Iron Body.						
2	$22.00	$18.00	½ in.	$5.00	$3.00	$1.10	$0.35	$10.00
3	30.00	25.00	¾ "	6.00	3.50	1.10	.35	11.50
4	42.00	35.00	1 "	7.00	4.00	1.10	.35	13.25
5	55.00	45.00	1¼ "	8.75	5.00	1.25	.62	16.75
6	70.00	55.00	1¼ "	8.75	5.00	1.25	.62	16.75
7	85.00	65.00	1½ "	10.50	6.00	1.25	.75	20.00
8	100.00	75.00	2 "	13.50	9.00	1.25	.90	27.50
9	115.00	85.00	2 "	13.50	9.00	1.25	.90	27.50
10	130.00	95.00	2 "	13.50	9.00	1.25	.90	27.50
12	150.00	115.00	2½ "	20.00	14.00	1.25	1.25	39.00

TERMS: Cash, upon delivery at our Works.

This injector is largely in use for stationary purposes.

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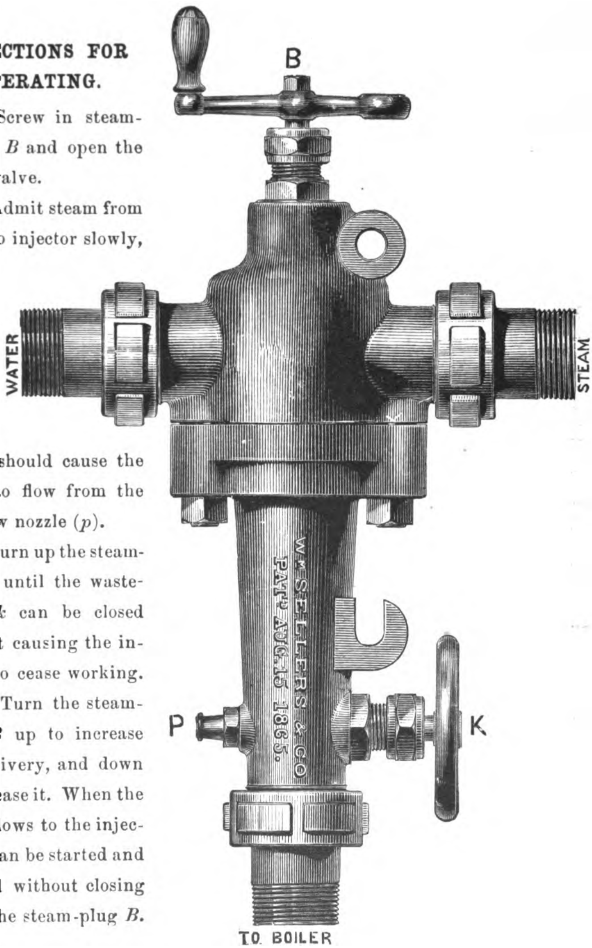
1873 SELF-ADJUSTING INJECTOR.



DIRECTIONS FOR OPERATING.

1st. Screw in steam-spindle *B* and open the waste-valve.

2d. Admit steam from boiler to injector slowly, which should cause the water to flow from the overflow nozzle (*p*).

3d. Turn up the steam-plug *B* until the waste-valve *k* can be closed without causing the injector to cease working.

4th. Turn the steam-plug *B* up to increase the delivery, and down to decrease it. When the water flows to the injector, it can be started and stopped without closing down the steam-plug *B*.

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EDGE MOOR IRON WORKS.

THE introduction of iron and steel into the construction of such engineering works as bridges, roofs, buildings, etc., has necessitated the establishment of manufactories devoted exclusively to this comparatively new industry, and in which the designs of engineers can be constructed in an accurate and inexpensive manner.

The Edge Moor Iron Works, situated on the river Delaware, about three miles above Wilmington, Delaware, and on the line of the Philadelphia, Wilmington and Baltimore Railroad, has work-shops fitted up with special reference to the production of engineering structures in iron and steel. One department of this establishment is devoted exclusively to hydraulic forging, for which has been fitted a specially constructed and patented plant, capable of producing large quantities at favorable rates. In such forgings as chord-links and other tension-bars a patented process is used, whereby the iron or steel is upset to the required shape without wrinkle or fold, and without any welded joint, insuring that the forged heads will have sufficient strength to rupture the bar, when such links are tested to destruction.

In the finishing department, chords, eye-bars, posts, and all similar work having two pin-holes are bored simultaneously in machines provided with movable boring heads, so arranged as to eliminate all differences in length due to change of temperature. All abutting joints of riveted work are machine-faced. Post-bearings and pin-holes in chord pieces are machine-finished at one operation,—*i.e.*, the holes are bored and the bearing surfaces are planed at one and the same setting in such a manner as to insure perfect parallelism between the face and the pin-hole. The riveted holes are multiple-punched, spaced by dividing machines, which accomplish accuracy of measurement and alignment in the various parts of any one structure, and insure their perfect matching when assembled in the pieces ready for riveting; and before riveting they

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are all reamed, obviating entirely the use of the gouge or drift-pin, and securing freedom from local strains produced by the use of the latter tool. The rivets are driven by hydraulic power with sufficient uniform pressure to draw the work properly together and to cause the metal of the rivet to flow into and fill the holes, thus attaining great strength, and avoiding the crystallization incident to repeated blows of a hammer on cooling rivets.

The accurate workmanship insured by the special appliances used at Edge Moor is supplemented by a system of rigid inspection during its construction and when completed, all of which prepares the work for ready and economical erection. Too much stress cannot be laid on this feature, the erection being an important element in the cost of engineering work.

The company is prepared to furnish designs for and manufacture iron work for bridges, roof-trusses, and buildings, bridge-pivots, wrought iron turn-tables, and engineers' manufactured work generally, and make specialties of hydraulic forgings and hydraulic riveted work.

The Edge Moor Company has become the sole licensee and manufacturer for the United States of the Galloway Boiler as improved under patents of 1875 and 1876. These boilers have acquired in England the distinction of being the most economical and efficient steam generators in use in that country, and they have largely superseded all other forms. The advantages possessed by them in a pre-eminent degree are safety, economy in fuel, low cost of maintenance, dry steam without superheating, large reserve power, and great longevity. They are made in sizes from 5 to 7 feet in diameter, and from 16 to 30 feet in length.

Post-office address of the principal office and works, Edge Moor Iron Co., Wilmington, Delaware.

PHILADELPHIA OFFICE,
1600 HAMILTON ST.

NEW YORK OFFICE,
79 LIBERTY ST.

WILLIAM SELLERS,
President.

ELI GARRETT,
Secretary and Treasurer.

GEO. H. SELLERS,
General Superintendent.

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THE MIDVALE STEEL COMPANY.

CAST STEEL.

THE uncertainties which attend the use of steel are due mainly to two causes,—1, to lack of accuracy on the part of the manufacturer; 2, to lack of knowledge on the part of the consumer as to what grade to use in a given case. The methods of the MIDVALE STEEL COMPANY, in manufacturing, are based upon the following assumptions:—That steels which are equally well melted, which have the same composition, and which are worked in the same way, are identical. That it is possible, from a knowledge of the composition of the raw material used, and by intelligent workmanship, to produce a given grade which shall be uniform in composition, and shall have received uniform treatment. That it is possible to check the results obtained by the chemical composition and the physical qualities of the metal when in a merchantable state. The policy of this company is to grade their steels according to their known composition and physical qualities, and to give their customers an opportunity to select metal suitable for any given use.

TOOL STEEL.

The difference in composition among the different grades of tool steel can be regulated and detected with great nicety; but they are so slight that they do not in all cases influence decidedly enough such physical qualities as tensile strength and ductility as to make a classification, based upon these qualities alone, one to be depended upon as a certain index of the value of the steels for special tools. Tool steels are therefore graded, first, according to quality, which is dependent upon the presence, in greater or less amounts, of certain substances other than carbon, which impair the general efficiency of the metal; second, according to hardness, which is principally dependent upon the varying amounts of *carbon* present in the steel.

According to quality, the Midvale brands of tool steel are "Warranted Cast Steel" and "Extra Warranted Cast Steel." Of each of these brands there are four regular grades,—No. 1 (very hard), made to order for special tools, etc. No. 2 (hard), most suitable for drills, reamers, taps, dies, and for the general run of machine tools. No. 3 (mild), to be used for chisels, gouges, sets,

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etc., and such tools as must endure blows. No. 4 (very mild), shear steel.

It is maintained that, for any given class of work, one of the above grades is the *best suited;* and, to obtain the best results, consumers should determine for themselves, by proper experiment, the question of which grade to use. In using steel, the general fact should be borne in mind that, within reasonable limits, the lower the heat at which any steel is worked and *hardened* the better will be the results obtained.

STEELS FOR CONSTRUCTIONAL PURPOSES,

such as machine forgings, axles, tires, springs, machinery, wire, boiler plates, bridge work, ship plates, ordnance purposes, etc., etc., are classified according to their physical characteristics, as follows, —test specimens 4″ long between measuring points:

Class.	Elastic Limit. Lbs. per Sq. Inch.	Ultimate Tensile Strength. Lbs. per Sq. Inch.	Per Cent. Elongation over 4 Inches after Fracture.	Per Cent. Reduction of Area at Point of Fracture.	
O	25,000	57,000	30	58	Will weld, and hardens but *very* slightly.
I	30,000	68,000	26	50	Hardens somewhat.
II	36,000	82,000	22	45	
III	41,000	93,000	18	38	
IV	47,000	105,000	14	30	
V	52,000	115,000	11	20	Hardens.
VI	56,000	125,000	9	15	
VII	61,000	135,000	6	10	

The choice of a grade of steel, depending upon its *physical characteristics*, but suited to any given purpose in construction, is a matter of utmost importance. There is often not only no advantage, but an absolute disadvantage, in using a steel not suitable for the work. This company has taken much pains to determine the grade or class of steel best adapted to certain purposes; and when consumers are in doubt, information and data will be furnished on application.

WORKS, OFFICE, AND POST-OFFICE ADDRESS,

NICETOWN, PHILADELPHIA.

WILLIAM SELLERS, *President.* MARRIOTT C. SMYTH, *Secretary and Treasurer.* R. W. DAVENPORT, *Superintendent.*

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WILLIAM SELLERS & CO.

THE house of William Sellers & Co. was started in 1848 as Bancroft & Sellers, and so continued until 1855, when upon the death of the senior partner the business passed into the hands of two brothers, William Sellers and John Sellers, Jr., who alone constituted the firm until 1873. It was the pioneer in the introduction of the present system of mill-gearing with interchangeable parts, and the manufacture of machinists' tools as a distinct branch of business.

In 1860 this firm introduced into America the celebrated GIFFARD INJECTOR, and were the sole makers of it in this country during the term of the original patent. They introduced the SELF-ADJUSTING INJECTOR in 1865. Then presented its still higher type in their " INJECTOR OF 1876," which is being rapidly introduced.

In 1860 they began the manufacture of the Morrison STEAM-HAMMER, and have improved that invention, adding greatly to its efficiency.

Their WORKS IN PHILADELPHIA are situated on the line of the Philadelphia and Reading Railroad, extending east and west from Sixteenth Street to Seventeenth Street, and north two squares to Buttonwood Street.

THEIR OFFICES:

AT THEIR WORKS,
1600 HAMILTON STREET,
PHILADELPHIA,

AND AT
79 LIBERTY STREET,
NEW YORK,

ARE ALSO THE OFFICES OF THE

EDGE MOOR IRON COMPANY,

Near Wilmington Del.

The firm, since 1873, *consists of*

WILLIAM SELLERS,
JOHN SELLERS, Jr.,
COLEMAN SELLERS,
J. SELLERS BANCROFT,
JAMES C. BROOKS.

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